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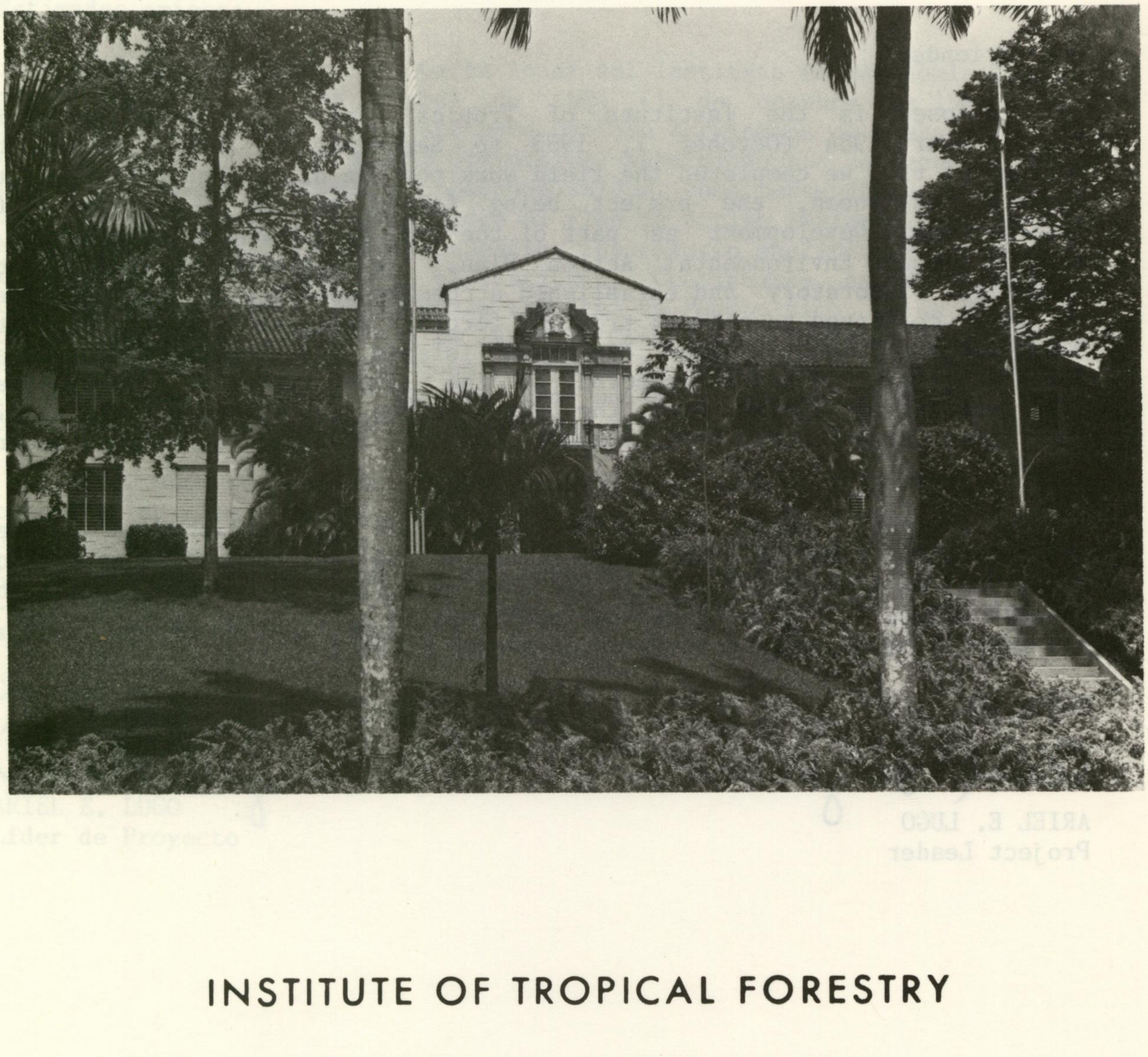

INSTITUTE OF TROPICAL FORESTRY

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September 1984

Dear Friends:

Enclosed is the Institute of Tropical Forestry's Annual Letter for fiscal year 1984 (October 1, 1983 to September 31, 1984). During this period of time we completed the field work portion of a large project in the Eastern Caribbean, the project being funded by the U.S. Agency for International Development as part of the U.S. government's contribution to the Caribbean Environmental Action Plan. We improved significantly our analytical laboratory and established a chemist position in the Institute. We also continued to conduct tropical forestry research in Puerto Rico, the U.S. Virgin Islands, other Caribbean islands, and throughout Central and South America. We are grateful to the large number of colleagues and Institutions in Puerto Rico, the United States, and throughout the tropics for their significant contributions to our tropical forestry research effort.

This year marks the fifth year since we published a complete bibliographic list of the publications of the Institute. It has been our intention to do so every 5 years and thus we include an updated list in this Annual Letter. Please share your publications on tropical forestry with us and keep in touch about activities of mutual interest.

Sincerely,

Ariel E Lugo

ARIEL E. LUGO
Project Leader

DEPARTAMENTO DE AGRICULTURA DE ESTADOS UNIDOS
ESTACION EXPERIMENTAL FORESTAL DEL SUR
Apartado AQ
Rio Piedras, Puerto Rico 00928
septiembre de 1984

Estimados amigos:

Adjunto incluímos la Carta Anual del Instituto de Dasonomía Tropical correspondiente al año fiscal de 1984 (1 de octubre de 1983 a 30 de septiembre de 1984). Durante este período terminamos el trabajo de campo de un proyecto en las Indias Orientales, subsidiado por la Agencia para el Desarrollo Internacional de Estados Unidos, como parte de la contribución del Gobierno de los Estados Unidos al Plan de Accion Ambiental del Caribe. Mejoramos significativamente nuestro laboratorio analítico y establecimos una posición de químico en el Instituto. Continuamos, además, llevando a cabo investigaciones de dasonomía tropical en Puerto Rico, Islas Vírgenes, otras islas del Caribe y a lo largo de Centro y Sur América. Agradecemos al gran número de Instituciones y colegas de Puerto Rico, Estados Unidos y demas países tropicales qué se han unido a nuestro esfuerzo por el desarrollo de la investigación de bosques tropicales.

Este año se cumplen cinco años de publicada la lista bibliográfica completa de las publicaciones del Instituto. Ha sido nuestra intención hacerlo cada cinco años, por lo que incluímos en esta Carta Anual dicha lista al día. Le exhortamos a que comparta sus publicaciones sobre bosques tropicales con nosotros y que se mantenga en contacto sobre aquellas actividades de interés mutuo.

Cordialmente,

Ariel E Lugo
ARIEL E. LUGO
Lider de Proyecto

INSTITUTE OF TROPICAL FORESTRY ANNUAL LETTER

1984

Table of Contents

Page

Research in Plantation Culture 1
L. H. Liegel

Research in Natural Forests 3
P. L. Weaver

Other Studies in Natural and Plantation Forests 5
A. E. Lugo

Puerto Rican Parrot Research 9
J. W. Wiley

Other Wildlife Research 12
W. J. Arendt

Cooperative Wildlife Research with the University of Wisconsin 14
E. Santana Castellon

Special Studies 16
F. H. Wadsworth

Other Activities 18
J. Feheley and A. E. Lugo

Appendix. Institute Publications (1939-1984) 45

CARTA ANUAL DEL INSTITUTO DE DASONOMIA TROPICAL

1984

Tabla de Contenido

Pagina

Investigaciones en el Cultivo de Plantaciones 25
L. H. Liegel

Investigaciones en los Bosques Naturales 28
P. L. Weaver

Otros Estudios en Bosques Naturales y en Plantaciones 30
A. E. Lugo

Investigaciones Sobre la Cotorra Puertorriquena 33
J. W. Wiley

Otras Investigaciones Sobre la Vida Silvestre 37
W. J. Arendt

Investigacion Cooperativa con la Universidad de Wisconsin Sobre la Vida Silvestre 39
E. Santana Castellon

Estudios Especiales 41
F. W. Wadsworth

Otras Actividades 42
J. Feheley y A. E. Lugo

Apendice. Publicaciones del Instituto (1939-1984) 45

RESEARCH IN PLANTATION CULTURE

Leon H. Liegel
Research Soil Scientist

Completed Research

The greater susceptibility to blow-down damage and mortality of young *Pinus oocarpa* over *Pinus caribaea* provenances in Puerto Rico on six sites, (6:1 for blow-down mortality and 2:1 for non-mortality damage [1980 and 1982-83 Annual Letter]) has also been observed in Australia, Fiji, and Thailand (Liegel, 1984). In some instances in Puerto Rico, linear and polynomial regression models were useful in relating damage to selected site and stand variables such as elevation, mean annual rainfall, 9-day storm rainfall, pre-hurricane mortality, and mean annual height and diameter increment for 5- to 6-yr-old trees. Before managerial guidelines for either wood or seed production can be developed, more local and international studies are needed to determine: 1) if certain environmental variables are usually associated with greater damage, 2) if susceptible provenances of either species are usually the fastest-growers and 3) if wind susceptibility is similar for both young and older trees.

Ten papers summarizing hurricane susceptibility of *P. caribaea* and *P. oocarpa* provenances and other *P. caribaea* var. *hondurensis* (Caribbean pine) trials were presented at the joint meeting of IUFRO working parties on provenances and genetic improvement strategies in tropical forest trees, Mutare, Zimbabwe in April 1984. One paper summarized 10-yr results for provenances of both species at one site in Anasco, Puerto Rico. All other trials were remeasured in 1983/84 on their ninth and tenth planting anniversaries and the final data analyses are still pending.

Some preliminary results from the Anasco site are:

- the Mt. Pine Ridge and Yucul *P. oocarpa* sources had slightly better total height and diameter growth but poorer survivals than top-ranked *P. caribaea* sources;
- consistently poorest performers were two Cuban and one Bahamas Islands sources for *P. caribaea*, and Malacatancito, Guatemala and Zapotillo, Honduras sources for *P. oocarpa* trials;
- provenances with best height and diameter growth for *P. oocarpa* at 5.7 yrs were still best performers at 10 yrs whereas best *P. caribaea* sources at 5.7 yrs were not always the best performers at age 10; and
- several Nicaragua *P. caribaea* var. *hondurensis* sources had similar or better height and diameter growth compared to the Mt. Pine Ridge, Belize, source, the most widely used source in local reforestation work since the 1960's.

Liegel and C.R. Venator, stationed at ITF from 1969-78, finished a 400-page technical guide to forest nursery management in the Caribbean and Latin America. The manuscript is now being edited. It outlines traditional labor intensive and highly mechanized bare root and containerized nursery systems, using many examples from Puerto Rico and other Caribbean countries. Either labor intensive or mechanized systems are suitable for reforestation work, depending on an individual country's source of labor, available monetary resources, and local reforestation/community needs and objectives.

A volunteer paper entitled "Issues of plantation forestry in watershed management on small Caribbean Islands in the 1980's" was presented at the 2nd Caribbean Foresters Workshop, Kingstown, St. Vincent, March 19-22, 1984. Conflicting and often competing watershed objectives are the biggest restraint to effective watershed planning. Inherent soil and topography conditions of small islands combine to create high soil losses, under both plantation and natural forested conditions.

On-going Research

In Jamaica, 42 growth and yield plots were established as part of a US-AID grant to study Caribbean pine in four countries of the Caribbean Basin. Soil samples were taken in each plot so that plot wood volumes and other stand characteristics such as foxtailing, cone production, and form could be related to several soil physical and chemical properties. Grant funds also sponsored: 1) a Venezuelan from CONARE (Corporacion Nacional de Reforestacion) to spend 6 months at North Carolina State University in Raleigh, to study tree improvement, forest genetics, and statistics and 2) a Jamaican Forestry Officer to spend 4 weeks in the Southern United States visiting Forest Service and university research centers studying insect and disease problems.

Cooperative research was initiated with the School of Forestry and Environmental Studies, Yale University, to undertake two projects with Caribbean pine in Puerto Rico. The first, part of an M.S. degree, involved taking 12 mm increment bore samples at breast height on six trees (2 foxtails, 4 nonfoxtails) in all plantings initially inventoried in 1975 (see growth and yield work, 1982-83 Annual Letter). Samples were taken in 27 plantings; analyses are continuing. The second project includes remeasuring all plots in the island-wide growth and yield study to determine periodic increment since last measurement, mean annual increments, and assessments of form, taper, and crown dimensions as indicators of site productivity. This work will continue through 1986.

Literature Cited

Liegel, L.H. 1984. Assessment of hurricane rain/wind damage in Pinus caribaea and Pinus oocarpa provenance trials in Puerto Rico. Commonw. For. Rev. 63(1):47-53.

RESEARCH IN NATURAL FORESTS

Peter L. Weaver
Research Forester

Research continued with trees and stands in secondary and primary forests, including studies mentioned in the last Annual Letter.

The Forest Resources of Puerto Rico
(Birdsey and Weaver 1983)

A summary of the 1982 report was prepared for the reading audience of the Journal of Forestry. Because this work was briefly described in the last Annual Letter, it will not be reviewed here.

Vegetation Survey on St. John Island, U.S. Virgin Islands
(Weaver and Woodbury 1983)

St. John's past includes occupation by the Arawaks, Caribs, and Danish colonists. The original forests were logged sporadically for ship building and shelter and later cleared for plantation agriculture. By the late 19th century many of the estates were abandoned, and common tree species regenerated. Today, most of the island is covered by secondary forest. In 1956, the Virgin Islands National Park was established, and now, the Park Service manages about three-quarters of the island.

The preliminary survey found about 85% of the species previously reported for the island as well as an additional 130 species not previously reported. Leguminosae was the most common family with 70 species, followed by Gramineae with 50 species and Euphorbiaceae with 35 species. About 20 species considered rare and endangered were also found.

On 31 sampling stations scattered throughout the Park Service lands, 127 tree species were identified. These were tentatively ranked by moisture preference. Summit forests were the richest in species composition and littoral forests had the fewest species.

Vegetation of St. John and Hassel Islands
(Woodbury and Weaver 1984)

The forests of St. John may be classified thus: mangrove, salt flat, and lagoon, 120 ha; moist forest including upland, 460 ha, gallery forests 205 ha, and basin forests 185 ha; dry evergreen formations including woodland, 1730 ha, thicket 1110 ha, thorn and cactus 325 ha, and coastal hedge/rock pavement 110 ha; secondary vegetation, 695 ha; pasture, 105 ha; and urban areas, 135 ha. The total area is 5180 ha. Common species were listed for each of these forest classifications.

Hassel Island is 54.2 ha in size and also contains mangrove, moist basin forest, dry evergreen thicket, thorn and cactus, coastal hedge/rock pavement, and _Acacia_, _Croton_, and _Leucaena_ scrub.

All species were classified by family and life form, and ranked by abundance within each forest type. St. John has 116 families and 792 species. Hassel Island contains 66 families and 297 species. Of the 18 species classified as rare and endangered, 6 may be new to science. Medicinal uses were described for many of the species.

Vegetation maps were produced for both islands and suggestions were included for management of the forest resources.

On-going Studies

The research on enrichment planting with hybrid mahogany in the Luquillo Experimental Forest is near completion. The study of hurricane effects on species composition and growth in the Colorado forest (subtropical lower montane wet forest) of the Luquillo Mountains is also nearly completed as is the vegetation study in the Cinnamon Bay watershed on St. John Island. These were all mentioned in the last Annual Letter.

Two additional studies nearing completion concern net primary productivity estimates in the dwarf forest (subtropical lower montane rain forest) in the Luquillo Mountains and the sampling of organic matter content of soils below secondary forests in Puerto Rico.

New Involvements

An inventory of the forests on the island of St. Vincent was started in January, 1984. The techniques used will closely follow those of the secondary forest inventory in Puerto Rico reported in the last Annual Letter. In addition, a survey of forest plantations was made and standing volumes and growth rates were estimated. Beginning in January, 1985, an update of the 1980 forest inventory of Puerto Rico will be conducted. Tree growth and stand composition changes will be available from this work.

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Birdsey, R.A. and P.L. Weaver. 1983. Puerto Rico's timberland. J. For. 81(10):671-672, 699.

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OTHER STUDIES IN NATURAL AND PLANTATION FORESTS

Ariel E. Lugo
Research Ecologist

Completed Research

A synthesis of the research history and opportunities in the Luquillo Experimental Forest (Brown et al. 1983) was published by the U.S. Forest Service. This document summarizes more than 200 scientific papers, products of more than 40 yr of research activity in the Luquillo Experimental Forest. Topics include hydrology, climate, geology, soils, summaries of state of understanding on the mayor forest ecosystems, disturbance history, and others. The document shows that the long-term data base for the Luquillo Experimental Forest is as strong as any set available for any other tropical forest in the world and perhaps as good as that of many temperate zone sites.

Another publication dealt with the synthesis of available volume data for tropical forests (Brown and Lugo 1984). Recent assessments of areas of different tropical forest types and their corresponding stand volumes were used to calculate the biomass densities and total biomass of tropical forests. Total biomass was estimated at 205 x 10^9 t (Table 1) and weighted biomass densities for undisturbed closed and open broadleaf forests were 176 and 61 t/ha, respectively. These values are considerably lower than those previously reported and raise questions about the role of the terrestrial biota in the global carbon budget.

Table 1. Biomass of tropical forests based on volume estimates (areas and volumes from 10).

	Closed forests*							Open forests†		
	Broadleaf			Conifer						
	Undisturbed-productive‡	Logged§	Unproductive‖	Undisturbed-productive‡	Logged§	Unproductive‖	Total	Productive‡	Unproductive‖	Total
Tropical America										
Area (10^6 ha)	452.98	53.50	147.45	1.53	13.64	9.56	678.66	142.89	74.11	217.00
Volume (10^9 m^3)	71.07	6.37	13.21	0.27	0.93	0.63	92.48	6.17	1.33	7.50
Stemwood biomass (10^9 tons)¶	43.92	3.94	8.19	0.13	0.43	0.29	56.90	3.81	0.82	4.63
Total biomass (10^9 tons)*	70.28	6.31	13.10	0.21	0.69	0.47	91.06	11.02	2.47	13.49
Biomass density (ton/ha)	155.1	117.9	88.8	136.0	50.4	49.2		77.1	33.3	
Tropical Africa										
Area (10^6 ha)	118.18	43.57	52.66	0.27	0.31	0.54	215.53	169.22	317.23	486.45
Volume (10^9 m^3)	30.3	8.41	7.35	0.05	0.02	0.07	46.21	4.68	3.76	8.44
Stemwood biomass (10^9 tons)¶	17.56	4.87	4.26	0.02	0.01	0.03	26.75	2.71	2.18	4.89
Total biomass (10^9 tons)#	28.09	7.79	6.82	0.03	0.02	0.05	42.80	7.83	6.54	14.37
Biomass density (ton/ha)	237.7	178.9	129.5	118.5	51.6	88.9		46.3	20.6	
Tropical Asia										
Area (10^6 ha)	97.26	94.62	100.08	1.77	3.83	2.80	300.36	8.53	22.42	30.95
Volume (10^9 m^3)	20.97	9.70	14.45	0.30	0.52	0.35	46.29	0.41	0.35	0.76
Stemwood biomass (10^9 tons)¶	11.93	5.51	8.24	0.16	0.27	0.18	26.29	0.23	0.20	0.43
Total biomass (10^9 tons)#	19.09	8.82	13.18	0.26	0.43	0.29	42.07	0.67	0.59	1.26
Biomass density (ton/ha)	196.3	93.2	131.7	144.9	112.5	103.6		79.0	26.32	
Total Tropics										
Area (10^6 ha)	668.42	191.69	300.19	3.57	17.78	12.90	1194.55	320.64	413.76	734.4
Volume (10^9 m^3)	122.35	24.48	35.01	0.62	1.47	1.05	184.98	11.26	5.44	16.70
Stemwood biomass (10^9 tons)¶	73.41	14.32	20.69	0.31	0.71	0.50	109.94	6.75	3.20	9.95
Total biomass (10^9 tons)#	117.46	22.92	33.10	0.50	1.14	0.81	175.93	19.52	9.60	29.12
Weighted biomass density (ton/ha)	175.7	119.6	110.3	140.1	64.1	62.8	147.3	60.9	23.2	39.7

*Closed forests are those whose forest stories cover a large proportion of the ground and lack a continuous dense grass layer. They may be evergreen, semi-deciduous, or deciduous, and wet, moist, or dry. †Open forests are mixed broadleaf-grassland tree formations with a continuous dense grass layer, and the tree canopy covers more than 10 percent of the ground. It is an ecological rather than physiognomic distinction, and in some cases the trees can cover the ground completely as with a closed forest. ‡Primary (virgin) or old secondary forests where there has been no logging for more than 60 years but which contain trees suitable for the wood industry. §Forests selectively harvested one or more times during last 60 to 80 years. This category also includes intensively managed forests. ‖Unproductive forests due to physical reasons (for example, poor form, rough terrain, or flooded) or legal reasons (for example, national parks or reserves). We used the volumes (m^3/ha) for the undisturbed productive forests to calculate biomass of the legally unproductive forests because national parks and reserves usually include high-volume tropical forests. However, the area in national parks and reserves accounted for about only 13 percent of the total unproductive category. ¶Calculated as the product of volume and average wood density by species group and region. #Product of stemwood biomass × 1.6 (from Table 1) for closed forests; product of stemwood biomass × 3.0 (average of the two values for open forests in Table 1) for open forests.

With the cooperation of several institutions (U.S. Department of Energy, University of Puerto Rico's Center for Energy and Environment Research, and the Tropical Science Center) the Institute published a provisional ecological map of the Republic of Brazil (Tosi and Velez-Rodriguez 1983). The map is in color (at 1:5,000,000 scale) and is accompanied by a 25 p narrative. Brazil contains three of seven latitudinal regions recognized under the life zone system: tropical (5.684 million km^2), subtropical (2.076 million km^2), and warm temperate (0.751 million km^2). The study describes 17 life zones (9 in the tropical, 5 in the subtropical, and 3 in the warm temperate region). In addition, the map identifies some 10 or 11 transitional zones. All are described in the narrative and the climatic data used to develop the map is also enclosed as an appendix.

As a first step towards the writing of a book on the forests of Puerto Rico, the Institute published in cooperation with the Department of Natural Resources, a compendium of articles describing the major forest types in Puerto Rico (Lugo 1983). The compendium contains 21 contributions mostly in Spanish by colaborators from the University of Puerto Rico, Commonwealth agencies, and other Institutions in Puerto Rico and abroad.

A survey of forest structure, species composition, and change in forest areas over a 44-year period was conducted on 39.5 ha of forest lands in Dorado, Puerto Rico, where H.A. Gleason and M.T. Cook had studied forest conditions in 1926 (Figueroa et al. 1984). A total of 51 tree species was found in the study area. Six forest types were identified on white sands and poorly drained clay soil. The most complex forest was the 19.7 m tall secondary forest with 32 tree species, 1,880 stems/ha, a basal area of 41.6 m^2/ha, and a complexity index of 493. Abandoned palm groves (5 tree species), a disturbed open forest with 9 tree species and dominated by _Hymenaea courbaril_, a Clusia-Zyzygium forest (11 tree species), and a young secondary forest with 19 tree species (also dominated by _H. courbaril_) were all undergoing succession towards the old secondary forest. This forest is considered to be the climax on white sands. In flooded soils, _Pterocarpus officinalis_ and six other tree species form a climax swamp forest that has not changed in composition for the last 54 years. In terms of forest area, however, _Pterocarpus_ and old secondary forests have been reduced by 30 percent and 79 percent, respectively. The primary cause of the changes in forest areas has been human intervention: direct, through cutting, and indirect, through changes in drainage conditions. The study forests, however, support four endangered plant species and an endangered bird species. The forests' social, scientific, and intrinsic values are significant.

An article on research training and needs in the tropics (Lugo and Brown 1984) was published in the proceedings of a conference-exhibit held in Paris to celebrate the tenth anniversary of the Man and the Biosphere Program. Training and research priorities for the tropics need re-evaluation because many of the existing documents on the subject are not based on comprehensive synthesis of the state of knowledge, contain numerous misconceptions, and their recommended priorities are out of focus. Examples in the article illustrate each of these problems and their consequences. Training and research priorities for the tropics must be coupled to management and peoples needs and to the limits on resource use and organic production imposed by natural laws. Efforts should be directed to filling existing gaps in knowledge and focused at an ecosystem or global level of biotic organization, levels where the most critical human problems are rooted. An organizational scheme for the fields of training, management, research, and planning is proposed to coordinate these activities in the tropics.

On-going Studies

The field portion of several studies was completed and manuscripts were prepared for publication. These include an ecosystem dynamics study in a palm floodplain forest (done in cooperation with J.L. Frangi), an assessment of growth and yield in *Anthocephalus chinensis* plantations (done in cooperation with J. Figueroa), a study on the structure and biomass of the Guanica dry forest, and another on the mineral cycles of the same forest (both done in cooperation with P.G. Murphy). In addition, we continue to cooperate with the U.S. Geological Survey and the Center for Energy and Environment Research in the study of watersheds in the islands of Dominica, Saint Vincent, and Saint Lucia. Studies in the Caribbean islands are funded by the U.S. Agency for International Development as part of their contribution to the Caribbean Environmental Action Plan. Other studies conducted under this project were described in the last Annual Letter and elsewhere in this Letter. The results of all completed studies will be discussed in future Annual Letters after the manuscripts or reports are published.

Manuscripts now in progress include one on the comparison of mineral cycles in plantation and natural forests, and another on the rate of biomass production and accumulation in tropical tree plantations. In addition, studies are in progress on the use of tropical tree plantations for biomass energy production and on the rate of wood decomposition under tropical moist conditions. Future Annual Letters will highlight results from these studies.

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PUERTO RICAN PARROT RESEARCH

James W. Wiley
U.S. Fish and Wildlife Service

Production and Survival of the Wild Puerto Rican Parrot Population

In August 1983, a minimum of 30 parrots survived in the Luquillo Experimental Forest. An all-forest count in February 1984 yielded a minimum of 29 Puerto Rican parrots. By August 1984, the population consisted of a minimum of 28 parrots, despite the addition of 4 fledgling parrots.

At the beginning of the 1984 nesting season, the adult breeding population consisted of the same individuals that laid eggs in 1983. Only one member of the known breeding cohort was lost during the 1984 season: the "West Fork" female (known since 1974 and producing eggs since 1975) disappeared late in the breeding season.

For the first time since 1981, when a new wild pair took over a nest site from the traditional "South Fork" parrot pair, a new pair of parrots was recruited into the breeding population. The significance of this event goes beyond the addition of a fifth breeding pair, the greatest number of breeding parrots since 1976. The new pair ("East Fork #3") had been observed exploring nest sites on the East Fork Lookout Ridge since 1982. Several artificial nest structures (constructed of polyvinyl chloride tubing) and improved natural cavities had been provided for the parrots in that area, and the pair had been observed exploring three of these sites. The pair's acceptance of one of these cavities is particularly important in that it represents a successful pioneering move by a parrot pair into an area not known to have had nesting parrots within the history of the research program (1968 to present). The pair selected a natural cavity that had been improved by project personnel.

Five wild parrot pairs laid a total of 21 eggs in 1984. Three pairs (West Fork, East Fork #1, East Fork #2) were experimentally double-clutched in an attempt to increase production. The first clutches of two of the pairs were not removed until late in the incubation period after it was determined that all eggs in one clutch (East Fork #1) were infertile, and only one of three eggs in the other (East Fork #2) clutch was fertile. All three pairs returned to their respective nests, but only the West Fork and East Fork #1 pairs produced second clutches. At least three of the four eggs produced by the West Fork pair were fertile, but due to the poor eggshell quality, none of the embryos survived. Neither of the two eggs produced in East Fork #2's second clutch was viable.

In total, 28.6% of the eggs (N = 6/21) laid by the wild population was fertile, a continuing trend of declining fertility among the wild population. The West Fork pair laid eight thin-shelled eggs and none hatched. The East Fork #1 pair laid four eggs but none was fertile. This pair consisted of a new male that replaced the traditional male (since 1974) who died of undetermined causes in 1983. The East Fork #2 pair produced one fertile egg of five laid. Two eggs of the three laid by the South Fork pair were fertile. The new parrot pair (East Fork #3) apparently produced only one inviable egg. That egg was not discovered until August when staff biologists were improving the cavity used by the new pair. The egg was laid late in the breeding season as the pair had not settled at the nest site when it was last examined in mid-April.

Three wild-produced chicks hatched, but only one fledged. One wild-produced chick died of undetermined causes at the South Fork nest. Its older sibling survived but later died from a massive infestation of the larvae of a new parasite, a soldier fly (Hermetia illucens). The soldier fly has not often been reported as a parasite of living birds and has been found in the South Fork nest in other years without apparent adverse effect on the parrot nestlings. After the loss of the South Fork chicks, another wild-produced chick (East Fork #2) was successfully fostered into the nest from which it fledged normally.

In total four chicks fledged from wild nests in 1984. Three were captive-produced birds fostered into wild-nests, and one was wild-produced. Two captive-produced Puerto Rican parrot chicks were fostered into the West Fork nest after the pair's eggs proved to be inviable. The chicks were immediately accepted by the traditional pair, but the broken-legged adult female disappeared late in the nesting period, leaving the male to care for the young alone. As a safety measure, two comparable-aged Hispaniolan parrot (Amazona ventralis) chicks were substituted for the Puerto Rican parrot nestlings until it could be assured that the male was caring for the young adequately. Complicating the situation, a new parrot moved into the nest area and paired with the traditional male. Initially, the new bird was not well accepted by the male, but was eventually tolerated at the nest and was allowed to enter the cavity. The male fed the new bird, but the presumed female did not participate in the care of the two chicks. Once the situation at the West Fork nest was judged stable enough to replace the Puerto Rican parrot chicks, they were substituted for the Hispaniolan parrots. Both birds (the same captive-produced parrots) were again accepted without problems, however neither chick fledged normally. One was not believed to have survived. The second chick was found to have a warble fly (Philornis [Neomusca] pici) infestation that left it unable to exit the cavity by the ladder and had to be taken into captivity for treatment. Its rehabilitation took several weeks and the bird was retained as part of the captive flock.

Development of a telemetry package suitable for parrots continued in 1984. Two parrot nestlings were fitted with new transmitter collars designed to drop off the birds after the batteries expire (about 3 months). Development of a telemetry monitoring system is essential for determining sources of early mortality and following movements of parrot fledglings so that management strategies for improved survival can be developed.

Post-breeding season efforts have been directed toward producing several additional improved natural cavities in anticipation of the

1985 breeding season. Sites are being established in areas where territorial, but as yet non-breeding, parrot pairs have become established in the East Fork and South Fork areas.

Captive Production of Puerto Rican and Hispaniolan Parrots

At the beginning of the 1984 breeding season, the captive Puerto Rican parrot flock consisted of 23 birds, including 9 females of egg laying age. Seven of these females laid a total of 34 eggs. Two females ("P2" and "P3") were in a traditional homosexual pair, five females were in heterosexual pairs, and two were unpaired. Two of the females in heterosexual pairs laid infertile eggs, and one unmated female also laid eggs. Only the same two pairs that have produced fertile eggs in the past laid viable eggs. Of the 34 eggs laid by all females, 11 (32.4%) were fertile, 13 eggs were laid by the 2 fertile pairs, of which 84.6% (11) were fertile, and 63.6% (7) of those hatched. All chicks survived to fledging.

Four of the seven captive-produced chicks were fostered into two wild nests (East Fork #2 and West Fork), but one was later removed from the West Fork nest after it developed a warble fly larvae infestation that endangered its survival at fledging time. The other three chicks fledged in the wild. Four captive-produced chicks were retained in captivity, bringing the flock size to 27 Puerto Rican parrots. The total world population (i.e., captive and wild populations) of Puerto Rican parrots stands at a minimum of 55 birds.

Several experiments were conducted as part of a continuing program to develop methods of increasing production of captive Puerto Rican parrots. Four of six egg-producing pairs were double clutched. All manipulated pairs produced replacement clutches, thereby increasing production from 33.3% to 100% (mean = 70.8 ± 27.8 [s.d.] %) above their first (unmanipulated) clutches.

Manipulation experiments with Hispaniolan parrots also yielded substantial increases in egg production. Six females Hispaniolan parrots (including one female without a mate) produced a total of 39 eggs, of which 69.2% (27) were fertile (79.4% of the eggs produced in heterosexual pairs). No manipulations were performed with three of the pairs, which produced an average of 4.3 ± 0.6 eggs per clutch. One pair of Hispaniolan parrots was experimentally induced to lay a replacement clutch (double-clutched as in the experiments with Puerto Rican parrots described above) consisting of 6 eggs (39.5% more eggs than produced in unmanipulated clutches). Two other females were induced to sequentially replace eggs as they were removed from the nest ("sequential replacement"). These females produced a mean clutch size of 10.0 ± 2.8 eggs, or 66.7% above the double-clutched female's production, and 132.6% more eggs than unmanipulated clutches.

Three young Puerto Rican parrots are being trained for an artificial insemination program. One of the males (18 months old) has formed a particularly strong bond with its human trainer, and has begun to courtship feed the handler, a positive sign of a good pair bond.

OTHER WILDLIFE RESEARCH

Wayne J. Arendt
Wildlife Biologist

Research in Puerto Rico

In cooperation with J. Faaborg from the University of Missouri, Columbia, mist netting and banding studies were continued in the Guanica Dry Forest in southwestern Puerto Rico. More data were obtained on the annual homing ability of wintering North American birds and their role in the avian community (Faaborg and Arendt, In press). While the data suggest much variation among individuals and species, migrant warblers appear to fit into two distinct groups: (1) stable community of warbler winter residents that appear to be fully integrated into the Guanica forest bird community, and (2) opportunistic warbler species whose populations vary greatly from year to year and who show little site fidelity. This latter group was most abundant between 1974-1980, when resident bird populations were low in response to repeated drought conditions during the resident birds' breeding season (May-July). Banding studies will continue in hopes of explaining the observed skewed sex ratios among wintering warblers, the area and habitats needed by the apparently more mobile species, the effect of resident densities on winter residents, and area-sensitivity in winter residents that show high levels of philopatry.

A 9-yr overview of banding studies (Faaborg et al., 1984) in the Guanica forest has shown that avian population fluctuations are proportional to the amount of rainfall, especially prior to and during the reproductive season. Resident species can coexist through severe drought conditions without any loss of species by simply dispersing throughout a larger area. Competition between these species during such "ecological crunches" has led to the fairly simple and conservative patterns of structure we find in West Indian bird communities.

Regional Research

Wildlife assessments were continued this year on eight Antillean islands (Antigua, Barbuda, Dominica, St. Lucia, St. Vincent, two islands in the Grenadines, and Montserrat).

The status of vertebrate wildlife in relation to their habitat needs was evaluated on each island. Although wildlife species, climate, vegetation composition, and the causes and extent of habitat disturbance varied from island to island, some general trends were observed.

- -Native forest types no longer exist or are greatly reduced. The resulting secondary vegetation is less suitable to native wildlife, of which many species are adapted to primary forest habitats.
- -Many of the abundant wildlife species are adapted to disturbed areas or are generalists that

can survive in a variety of natural or disturbed habitats.

- -Introduced animals continue to pose a serious threat to native fauna and flora.

- -Deforestation continues to threaten the preservation of native fauna and flora.

In cooperation with the Montserrat National Trust, wildlife assessments were conducted to study the status, distribution, and reproductive ecology of the national bird of Montserrat, the Montserrat Oriole (Icterus oberi).

The largest concentrations of orioles were found in the South Soufriere Hills region of Montserrat in mesophytic forest beginning at an elevation of 336 m near the "bamboo forest" and continuing up through hygrophytic forest to an elfin woodland at 671 m elevation known locally as "Upper Pond". Eight breeding pairs were found per km^2. Orioles were not found, however, at the summit of Montserrat's highest mountain, Chance's Peak (915 m), where the elfin woodland, consisting mostly of palm brake, has been constantly impacted by high winds and occasional hurricanes. Nor were orioles found in the highly degraded secondary growth on neighboring Gage's Peak. Orioles were found in the steep-sided gorges separating the two peaks. Despite a lower concentration of orioles (only 3 breeding pairs per km^2) in the secondary vegetation of a mesophytic forest stand in the Centre Hills, oriole pairs were found in the riparian vegetation bordering streams down the wet gorges and well into the lowlands. Only occasional oriole pairs were found in the highly degraded secondary vegetation at Killiekrankie Waterworks. No orioles were found in xerophytic forests, although occasional individuals have been reported seen in such areas. Intensive studies were also made of the oriole's reproductive ecology and these studies are being prepared for publication.

Literature Cited

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Faaborg, J., and W.J. Arendt, and M.S. Kaiser. 1984. Rainfall correlates of bird population fluctuations in a Puerto Rican dry forest: a 9-year study. Wilson Bull. 96(4):577-595.

COOPERATIVE WILDLIFE RESEARCH WITH THE UNIVERSITY OF WISCONSIN

Eduardo Santana Castellon
Wildlife Biologist

In 1984 I completed wildlife studies with Dr. Stanley A. Temple of the Department of Wildlife Ecology, University of Wisconsin. This research was the basis for my M.S. thesis.

Red-tailed Hawks

I found high densities of Red-tailed hawks in the Luquillo Experimental Forest. Densities were higher than those in lowland areas adjacent to the forest and those reported for North America. Reproductive success was normal in the lowlands but low in the rain forest. An apparent cause for this phenomenom was the frequent rain that reduced the feeding rate near rain forest nests. A pronounced change in the diet composition ot the hawks occurred along an altitudinal gradient, from one dominated by mammals in the lowlands to one dominated by herps and birds in the mountain cloud forest. Activity patterns of red-tailed hawks were studied by following individuals equipped with radio-transmitters. Red-tailed hawks were a threat to endangered Puerto Rican parrots in parrot breeding and feeding valleys.

A detailed study on the structure of red-tailed hawk nest sites was conducted in cooperation with Eddie N. Laboy of the Department of Natural Resources of Puerto Rico and James A. Mosher of the University of Maryland. Red-tailed hawks were found to nest in trees that were taller than the mean canopy height for the stand. They nested on horizontal branches within the upper quarter of the tree. Vines were an important source of nest support in moist habitats but not in dry habitats. Nest sites were found most often on the upper half of hillsides in areas buffered from human disturbance. Vegetation and topographic characteristics converged in allowing red-tailed hawks to view large portions of their territories from the nest. Contrasts were made between tropical and temperate nest sites. The major features of red-tailed hawk nest sites were described to aid wildlife managers in assesing the quality of forest patches for red-tailed hawks in Puerto Rico. Recommendations regarding the sport of falconry were provided to the Department of Natural Resources.

Parrot Radio-Transmitters

A radio-transmitter model was developed in cooperation with the U.S. Fish and Wildlife Service to help parrot-project researchers determine the movements and sources of mortality of Puerto Rican parrots. The usual transmitter designs (e.g., harness, tail, glu-on, and tarsal mounts) did not work well with parrots. An adjustable neck-collar model with a single-loop antenna was the only system of radio attachment that parrots tolerated. This model was designed so that it would fall off the parrot's neck after the battery died. Transmitters modelled after the one described here were tested by Dr. James W. Wiley of Patuxent Wildlife Research Center in parrot release experiments in the Dominican Republic.

Turkey Vultures

Studies on the biology of Turkey Vultures in Puerto Rico were conducted incidental to studies on red-tailed hawks. Greg Potter, a high school student resident of Puerto Rico, collaborated on this project. Logistical support was provided by Sean Furniss of the Cabo Rojo National Wildlife Refuge and Dr. Jose Vivaldi of the Department of Natural Resources. Victor Apanius (University of Wisconsin) assisted in this study and conducted his own research on the structure and concentration of vulture immunoglobulins. Turkey Vulture density increased gradually from east to west along the south coast of Puerto Rico. Density was correlated with climatic and land-use patterns. Soaring activity was highest between 10:00 and 17:00 hours. Home range size, movement pattern, and use of roosts were studied by monitoring a vulture equipped with a radio-transmitter.

Research in Costa Rica

With the support of the Institute of Tropical Forestry and the Organization for Tropical Studies, I travelled to Costa Rica to study how fruit properties and feeding behavior affect the feeding choices of neotropical frugivorous birds. This work was conducted in cooperation with Drs. Timothy C. Moermond and Julie S. Denslow of the Departments of Zoology and Botany of the University of Wisconsin. Feeding experiments were performed with captive collared Aracaris and Slaty-tailed trosons. These species are considered to be important dispersal agents for trees with large-seeded fruits (e.g., Lauraceae and Myristicaceae) and they exhibit the two most extreme adaptations for feeding on fruits. Aracaris (toucans) hop actively in the canopy and take most of the fruits from a perch by using their long bills. In contrast, trosons rarely walk and invariably take fruits on the wing. The birds showed strong preferences among fruits differing in size, ripeness, color, accessibility, height above the ground, and distance to surrounding leaves. However, the two species responded differently to these properties suggesting the presence of different underlying criteria consistent with their foraging abilities.

SPECIAL STUDIES

Frank H. Wadsworth
Research Forester

The major project in this section of the Institute, the preparation of a manuscript for a book on forest production for Tropical America, moved into its final stages. Three chapters have been edited, peer reviews have been received on four others, and two more are about ready, leaving two chapters needing completion. A bibliography of some 3,500 references has been entered on a word processor to facilitate final screening and uniformity of format.

An analysis of 30-year diameter growth of some 1600 trees of potential timber species in ecologically stable stands in the Luquillo Experimental Forest (subtropical wet) is showing a significant relationship to site, to different time periods, and growth prediction factors. Table 1, presenting 24-year data for the 6 most abundant species, illustrates the great degree of uniformity of mean growth rates against which individual variations are being compared. Analysis is proceeding in cooperation with Yale University.

A new study of timber tree plantation performance in Puerto Rico and the Virgin Islands was begun. Records of hundreds of past studies throughout the area have been screened for possible consolidated presentation. Some 200 plantations have been selected for a final assessment in the field. Of these, 18 have been remeasured.

Four issues of ISTF NEWS, the quarterly newsletter of the International Society of Tropical Foresters were generated in Puerto Rico for publication by the Society of American Foresters and distributed world-wide to more than 1000 members. The newsletter is a product of review of world-wide

Table 1. Mean tree characteristics and 24-year growth for 6 species in tabonuco forest.

Species	Trees measured	Diameter at breast height		Ratio of crown to total height	Basal area growth
		1957	1981	1981	1957-81
		(cm)			(cm^2)
Manilkara bidentata	118	18.0	23.4	0.43	174
Matayba domingensis	142	17.2	21.8	0.37	144
Ormosia krugii	109	20.8	24.9	0.38	144
Tabebuia heterophylla	270	15.7	20.1	0.36	124
Didymopanax morototoni	120	17.0	21.1	0.29	124
Dacryodes excelsa	357	28.7	31.2	0.35	121

tropical forestry accessions to the library of the Institute. This includes assessing the importance of journal articles and preparing reviews of those considered most significant. During the year 75 publications were described, and major reviews made of several books. The newsletter is now being published in French, as well as English and Spanish.

OTHER ACTIVITIES

JoAnne Feheley and Ariel E. Lugo
Library Technician and Project Leader

Institute staff are required to participate in insular, national, and international activities that promote tropical forestry research and/or disseminate results of research activity. These activities are summarized in Tables 1 and 2. In addition, the

Table 1. Activities participated in by Institute staff during FY 1983-84.

Commonwealth of Puerto Rico	National	International
° Lectures, field trips and study guidance on silviculture and forest ecology given to graduate students from various campuses of the University of Puerto Rico. ° Counsel on research plans presented during meetings and field trip to to U.S. Navy property on the Island of Vieques. ° Participation with Land Management Planning Team for the Caribbean National Forest (Luquillo Experimental Forest). ° Participation in the Puerto Rico Coastal Zone Management Program of the Puerto Rico Department of Natural Resources. ° Presented papers at First Symposium on Island Ecological Systems sponsored by the Interamerican University. ° Various special consultations to the Puerto Rico Department of Natural Resources. ° Judged Science Fairs and high school science congress for the Commonwealth government. ° Lectures to science teachers from the Association of Science Teachers of Puerto Rico. ° Prepared position paper on environmental quality for the Presbyterian Church of Puerto Rico. ° Advised Center for Energy and Environment Research on research direction and priorities. ° Chaired Advisory Committee on Botanical Garden of University of Puerto Rico. ° Advisor, Committee for Puerto Rico Environmental Quality Board.	° Invitational lectures on tropical silviculture before students, faculty and general public in School of Forestry, Purdue University. ° Lectures, field trips and study guidance to graduate students in in silviculture and forest ecology from Yale University and several other US universities. ° Filming of a television program for National Public Television on the carbon cycle of tropical ecosystems. ° ° Papers presented at Symposium of American Association for the Advancement of Science. ° Lectures at the University of Tennessee on tropical forestry. ° Collaborated in cloud chemistry study at the Ecosystem Center of the Carey Arboretum. ° Reviewed papers for National Journals and granting agencies. ° Participation in Pannel for Assessment of AID Forestry Program. ° Participation as a Director, America Forestry Association.	° Key lecture presented and week-long review of Jamaica's forestry made for Jamaica Society of Scientists and Technologists. ° Papers presented at joint meeting of IUFRO Working Parties on Provenances and Genetic Improvement Strategies in Tropical Forest Trees, Mutare, Zimbabwe. ° Presented papers at 2nd Caribbean Foresters Workshop, Kingston, St. Vincent. ° Participation in task force seeking to develop jobs in the Dominican Republic. ° Established watershed monitoring project in three Caribbean islands: St. Lucia, St. Vincent, and Dominica. ° Orientations to visitors from Dominican Republic, Peace Corps, from various islands, and from other countries. ° Editor of quarterly newsletter of International Society of Tropical Foresters. ° Member of Editorial Board of various international journals. ° Participation 12th Session, FAO North American Forestry Commission. ° Led team assessing forestry program of CATIE, Costa Rica. ° Paper at Mangrove Workshop in Penange, Malaysia. ° Guest speaker on status of Montserrat's Wildlife, University of the West Indies, Montserrat. ° Guest speaker (on wildlife) at the Inner Council Chambers of the Montserrat Government.

Table 2. Committee or delegations with Institute staff participation. Chairmanship by Institute staff is indicated by (*).

Commonwealth of Puerto Rico	National	International
° Board of Directors of the the Botanical Garden of the University of Puerto Rico.	° Membership on Board of Directors of the American Forestry Association.	° Co-chairmanship by and meeting at the Institute of the Silviculture Working Group of the FAO North American Forestry Commission that presented progress report at the XII Session of the Commission in El Paso, Texas (*).
° Puerto Rico Conservation Trust.	° Member of the U.S. Agency for International Development committee of five preparing recommendations for improving forestry component of the program of that agency.	° Team for assessment of the forestry research program of the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) at Turrialba, Costa Rica (*).
° Environmental Policy Advisory Committee of the Puerto Rico Environmental Quality Board.	° U.S. Man and the Biosphere Program tropical and subtropical forest directorate (*).	° Caribbean Foresters Workshop, Kingston, St. Vincent (*).
° Puerto Rico Science Teachers Association.	° Forest advisory committee to the 10th Naval District concerning reforestation of Vieques Island.	° Research Committee of the FAO Latin American Forestry Commission (*).
° Senior advisory committee to the President of the University of Puerto Rico.	° Wetlands Technical Council.	° IUCN Commission on Ecology Mangrove and Tropical Forests Working Group.
° Jobos Bay Estuarine Sanctuary Management Committee.		
° Technical advisory committee for the Coastal Zone Management.		

Institute hosted many visitors (Table 3) and conducted a number of important activities reported below. In October, 1983 the Institute hosted the research committee of the Latin American Forestry Commission. The committee

Table 3. Visitors to the Institute, FY 1983-84.

Name	Institution	Place
Alexander Cruz	University of Colorado	Boulder, Colorado, USA
Jose A. Nuñez Arias	Instituto Superior de Agrícola	Dominican Republic
José Mercedes	Instituto Superior de Agrícola	Dominican Republic
Douglas M. Knudson	Purdue University	Lafayette, Indiana, USA
Merlio Morell		Dominican Republic
Wartono Kadri, General Director	Reforestation and Land Rehabilitation	Indonesia
Bambang Sukartiko, Director	Soil Conservation	Indonesia
R. Otto Horwarth	Nabisco Brands	Wilton, Connecticut, USA
Phoebe T. Lansdale, Program Officer	Pan-American Development	Washington, DC, USA
Mervin Stevens	Forestry Support Program (USAID-US Forest Service)	Washington, DC, USA
David Harcharik, Director	International Forestry Division, US Forest Service	Washington, DC, USA
John Hoffnagle, Director	Tropical Research Institute, Yale University School of Forestry and Environmental Studies	New Haven, Connecticut, USA

Table 3. (cont.).

Name	Institution	Place
John Gordon, Dean	Yale University School of Forestry and Environmental Studies	New Haven, Connecticut, USA
Alberto Rodríguez, Coordinator	Peace Corps, Government of the Dominican Republic	Dominican Republic
Craig Fredrickson, Coordinator	Peace Corps	Washington, DC, USA
Peter Hannah	University of Vermont	Burlington, Vermont, USA
Thomas Siccama	Yale University School of Forestry and Environmental Studies	New Haven, Connecticut, USA
Thomas Stadtmuller	Centro Agronomico Tropical de Investigacion y Enseñanza (CATIE)	Turrialba, Costa Rica
Joseph Miller, Librarian	Yale university School of Forestry and Environmental Studies Library	New Haven, Connecticut, USA
James Michael Call, Volunteer	Peace Corps	St. Lucia, West Indies
Raymond Philen, Volunteer	Peace Corps	Dominica
Shah Ali Iman, Conservator of Forests	Department of Forestry	Bangladesh
A.Z.M. Shamsul Huda, Deputy Conservator of Forests	Department of Forestry	Bangladesh
Peter G. Murphy	Department of Botany and Plant Pathology, Michigan State University	East Lansing, Michigan, USA
Sandra Brown	Department of Forestry, University of Illinois	Urbana, Illinois, USA
Armond Joyce	NASA	Picayune, Mississippi, USA
Steve Sader	NASA	Picayune, Mississippi, USA
Ernesto Medina	Instituto Venezolano de Investigaciones Cientificas	Caracas, Venezuela
Elvira Cuevas Viera	Instituto Venezolano de Investigaciones Cientificas	Caracas, Venezuela
Jorge L. Frangi	Faculta de las Ciencias Naturales y Museo, Museo de La Plata	La Plata, Argentina
Carlos Marx Ribeiro Carneiro, Director	Project PNUD/FAO/IBDF/BRA82-008	Brasilia, Brazil
Juan Moya Cerpa	Corporacion Nacional Forestal	Santiago de Chile, Chile
Rafael Eduardo de la Torre	Asociación Colombiana de Reforestacion	Medellin, Colombia
Gilbert Canet Brenes	Direccion General Forestal	San Jose, Costa Rica
Ruben Guevara M.	Corporacion Hondureña de Desarrollo Forestal	Siguatepeque, Honduras
Miguel Caballero Deloya	Instituto Nacional de Investigaciones Forestales	Coyoacan, D.F., Mexico
Rodolfo Salazar	Departamento de Recursos Naturales Renovables	Turrialba, Costa Rica
John Palmer	Programa de Cooperacion Tecnica del Gobierno Britanico	Turrialba, Costa Rica
Italo Russo	USAID	Santo Domingo, Dominican Republic
Francisco Barroso P.	Ministerio del Ambiente y de los Recursos Naturales Renovables	Messanina, Caracas, Venezuela

Table 3. (cont.).

Name	Institution	Place
Marilyn Headly	Department of Forestry and Soil Conservation	Jamaica
Albert S. Carlo	Chas. T. Main International Assessment	Boston, Massachusetts, USA
David F. Jenkins	Chas. T. Main International Assessment	Boston, Massachusetts, USA
Wally Parham	Office of Technical Assessment (OTA)	Washington, DC, USA
Kris W. Thoemke, Manager	Rookery Bay National Estuarine Sanctuary Bureau of Environmental Land Management, State of Florida	Naples, Florida, USA
David M. Smith	Yale University School of Forestry and Environmental Studies	New Haven, Connecticut, USA
Diego Echevarria	Terra Productions Inc.	New York, New York, USA
Lawrence Mosher	National Journal	Washington, DC, USA
Joshua C. Dickinson, III	Environmental Management Consultant	Gainesville, Florida, USA

developed a work plan that included a synthesis of plantation yields in Latin America. The data required for this synthesis have been collected cooperatively by many countries and are being analyzed in Costa Rica.

The Institute was also instrumental in organizing the second meeting of Caribbean Foresters in Kingstown, Saint Vincent, and the Grenadines during the week of March 19, 1984. The meeting was sponsored by U.S. Man and the Biosphere Program, through its Directorate on Tropical Forests. A total of 57 people from nine islands attended. Also at the meeting were representatives from three additional countries (Canada, Haiti, and U.S.A.); and six other institutions (Canadian International Development Agency, U.S. Agency for International Development, Organization for American States, U.S. Forest Service, University of Illinois, and the U.S. Geological Survey.

The meeting was dedicated to watershed management. Each island presented a paper summarizing the state of watershed programs and problems. Then, technical presentations on the subject were made by invited specialists. All presentations will be edited for publication in a meeting proceedings.

Among the primary objectives of the meeting were the fostering of communication among island foresters, reviewing of forestry activities taking place in the Caribbean, discussion of problems of common interest, and the development of an agenda for coordinated future action in the area of watershed management. Meeting participants developed a series of recommendations to all institutions concerned with watersheds in the Caribbean. The recommendations took the form of a proposal for integrated action on island watersheds.

The key findings of the workshop were that:

-Watershed management is critical for the maintenance of the

Caribbean islands limited natural resources e.g., land, forest, soil, water, wildlife, and coastal ecosystems. Without the proper natural resource base, economic development in Caribbean islands cannot be sustained.

-Natural resources of the island countries are a cornerstone of their development. The forestry sector, through its watershed management activities can make significant contributions towards the goal of optimizing and perpetuating the contribution of natural resources to island economies.

Because the forestry sector of the Caribbean islands has been neglected for many years, it is necessary that this sector be upgraded to the point where it can perform its role in the economy optimally.

The workshop recognized that:

-Watershed problems have gradually become more and more severe and actions are needed immediately to conserve options that may be lost if the present inaction continues.

-The financial resources to address these concerns is frequently beyond the means of small island states. Therefore, we look to the international development community to assist us in carrying out this much needed effort.

Workshop recommendations were:

-That already developed state of the art technology be applied to island problems. These technologies may mitigate the decades of neglect in the sector and provide powerful problem-solving tools that have proven useful in other regions of the world.

-That a coordinated development of a watershed management program be implemented and integrated into a comprehensive forestry sector strategy.

Yale University, in cooperation with the Puerto Rico Department of Natural Resources and with funding from the Mellon Foundation, has established a Tropical Research Institute that will use Puerto Rico as a base for graduate student research. The Institute (ITF) cooperated with this effort, and we anticipate a mutually beneficial exchange of scientific information among all participating institutions.

This fall, J. Feheley attended a meeting sponsored by the Information Systems staff of the U.S. Forest Service, Washington, D.C. Research information centers of the Agency were represented. They formulated recommendations to be presented to the Chief of the Forest Service for a scientific/technical information system, or network, that will more effectively supply Forest Service employees and others with the information they need. The proposed network would include an on-line public access bibliographic file, and expansion of the Institute's current awareness and document delivery services.

A bibliography of forestry in Puerto Rico, compiled by Menandra Mosquera and JoAnne Feheley was published in September 1984 as Southern Station General Technical Report SO-51. This partially annotated bibliography provides sources of literature covering Puerto Rico's practice of forestry and allied fields, and includes references written between 1889 and 1978.

The Institute entered into the following cooperative research agreements during the year: Jamaica Department of Forestry and Soil Conservation; Corporacion Nacional de Reforestacion Venezuela (CONARE); North Carolina Agricultural Research Service, School of Forest Resources, North Carolina State University, Raleigh, North Carolina, USA; Montserrat [West Indies] National Trust; Yale University School of Forestry and Environmental Studies, New Haven, Connecticut, USA.

Versión en Español

INVESTIGACIONES EN EL CULTIVO DE PLANTACIONES FORESTALES

Leon H. Liegel
Científico en Investigaciones de Suelos

Investigaciones terminadas

La mayor susceptibilidad de las procedencias de árboles jovenes de Pinus oocarpa, en comparación con el Pinus caribaea en relación a la mortalidad por el derribo causado por el viento en seis sitios en Puerto Rico; (6:1 y 2:1 debido a los daños que no produce mortalidad [Carta Anual 1980 y 1982-83]) también ha sido observada en Australia, Fiji, y en Tailandia (Liegel, 1984). En algunos casos en Puerto Rico, modelos de regresiones lineales y polinomiales fueron de utilidad al relacionar el daño en sitios selectos a variables en el rodal tales como: elevación del sitio, lluvia anual promedio, lluvia en tormentas de 9 días de duración, mortalidad pre-huracán, y crecimiento anual promedio en altura y en diámetro para árboles de 5 a 6 años de edad. Antes de determinar las guías administrativas, para tanto la producción de madera como de semillas, se necesitan más estudios locales e internacionales para poder determinar: 1) si ciertas variables ambientales están generalmente asociadas con el daño mayor, 2) si las procedencias susceptibles de una u otra especie son generalmente las de mayor crecimiento y 3) si la susceptibilidad a la fuerza del viento es semejante para ambos los árboles jovenes y los árboles más viejos.

En la reunión conjunta de los grupos de trabajo de "IUFRO", que estudian las procedencias y las estrategias de mejoramiento genético en árboles de los bosques tropicales, celebrada en Mutare, Zimbabwe en abril de 1984, se presentaron diez ponencias resumiendo la susceptibilidad a los huracanes de las procedencias de P. caribaea y P. oocarpa u otros trabajos con el P. caribaea var. hondurensis (pino Caribe). Una ponencia resumió resultados cubriendo 10 años para las procedencias de ambas especies en un lugar o sitio en Añasco, Puerto Rico. Todas las otras pruebas se remidieron durante el 1983/84 en sus aniversarios noveno y décimo de plantados y los análisis finales de los datos todavía están pendientes.

Algunos resultados preliminares del sitio de Añasco son:

- las procedencias "Mt. Pine Ridge" y Yucul de P. oocarpa tuvieron una altura total y crecimiento en diámetro ligeramente mejores, pero supervivencias peores que las procedencias consideradas del P. caribaea;
- dos procedencias de P. caribaea originadas en Cuba y una en las Islas Bahamas resultaron consistentemente peores, al igual que las procedencias de Malacatancito, Guatemala y Zapatillo de Honduras en las pruebas de P. oocarpa;
- las procedencias con el mejor crecimiento en altura y en diámetro del P. oocarpa a los 5.7 años todavía fueron las mejores a los 10 años, mientras

que las mejores procedencias del P. caribaea a los 5.7 años no fueron siempre las mejores a los 10 años; y

- algunas procedencias del P. caribaea var. hondurensis oriundas de Nicaragua tenían igual o mejor crecimiento en altura y en diámetro, en comparación con la procedencia "Mt. Pine Ridge", Belice, la fuente de semilla más ampliamente usada localmente en trabajos de repoblación desde los años sesenta.

Liegel y C.R. Venator, con base en el Instituto de Dasonomia Tropical del 1969-78, terminaron una guía técnica de 400 páginas para el manejo de viveros forestales en el Caribe y en América Latina. El manuscrito está siendo editado. Describe sistemas tradicionales de trabajo manual intensivo y sistemas altamente mecanizados de producción de plantas a raíz desnuda o contenidos en recipientes, utilizando numerosos ejemplos de Puerto Rico y de otros países del Caribe. Ambos sistemas, de labor intensiva o mecanizadas se prestan para llevar a cabo trabajos de repoblación, dependiendo de las fuentes de mano de obra, recursos y monetarios disponibles, y las necesidades y objetivos de repoblación del país.

En el 2do Taller de Trabajo de Dasónomos del Caribe en Kingstown, St. Vincente, en marzo 19-22, 1984, se presentó un trabajo voluntario titulado "Interrogantes sobre el efecto de plantaciones forestales en el manejo de cuencas en las islas pequeñas del Caribe en los (años) ochenta". Objetivos en conflicto, y a veces competitivos en el uso de cuencas, son los mayores obstáculos para la planificación efectiva de las cuencas hidrográficas. Las condiciones inherentes en el suelo y en la topografía de islas pequeñas se combinan para producir altas pérdidas de suelo, aun bajo la proteccion de plantaciones y del bosque natural.

Investigaciones en Progreso

En Jamaica se establecieron 42 parcelas de ensayo para estudiar el crecimiento y la producción, como parte de una donación de la Agencia de los Estados Unidos para el Desarrollo Internacional (AID), para estudiar el pino del Caribe en cuatro países de la Cuenca del Caribe. En cada parcela se tomaron muestras del suelo de modo que el volumen de madera y otras características del rodal, tales como el hábito de rabo de zorro, producción de conos y forma del árbol, pudieran relacionarse con varias características físicas y químicas del suelo. Fondos provenientes de donaciones también patrocinaron: 1) a un ciudadano de la Corporacion Nacional de Reforestación (CONARE) para asistir durante 6 meses a la Universidad Estatal de Carolina del Norte en Raleigh, para estudiar mejoramiento del árbol, genética forestal, y estadísticas y 2) un oficial forestal de Jamaica para pasar 4 semanas en el sur de los Estados Unidos visitando centros de investigaciones del Servicio Forestal y de las universidades para estudiar los problemas causados por los ataques de los insectos y las enfermedades.

Se inició una investigación cooperativa con la Escuela de Dasonomía y Estudios Ambientales de la Universidad de Yale, para llevar a cabo dos estudios con pino hondureño o pino del Caribe en Puerto Rico. El primero es parte del trabajo para grado de "M.S.", incluye la toma de muestras de barrenos de incremento de 12 mm, a la altura del pecho en seis árboles

(2 con rabo de zorro, 4 normales) en todas las plantaciones inventariadas inicialmente en el 1975 (véase trabajo en crecimiento y producción, Carta Anual, 1982-83). Se tomaron muestras en 27 plantaciones; los análisis continuan. El segundo proyecto consiste en remedir todas las parcelas de crecimiento y producción en toda la isla para determinar el crecimiento periódico desde la última medición, incrementos anual promedio, y evaluaciones de forma, conicidad y dimensiones de la copa, como indicadores de la productividad del sitio. Este trabajo se continuará a lo largo del 1986.

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INVESTIGACIONES EN LOS BOSQUES NATURALES

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La investigación se continuó con árboles y rodales en bosques secundarios y primarios, incluyendo los estudios mencionados en la última Carta Anual.

Los Recursos Forestales de Puerto Rico

(Birdsey y Weaver 1983)

Se preparó un resumen del informe de 1982 dirigido a los lectores del "Journal of Forestry". No lo revisaremos aqui, ya que este trabajo se describió brevemente en la última Carta Anual.

Reconocimiento de la Vegetación en la Isla de St. John, Islas Virgenes Americanas

(Weaver y Woodbury 1983)

En el pasado, St. John fué ocupado por indios Arawacos y Caribes, y por colonos daneses. Los bosques naturales se usaron esporádicamente para construcción de barcos y de casas, y más tarde se talaron para establecer plantaciones agrícolas. Hacia el final del siglo XIX muchas de las plantaciones se abandonaron y se regeneraron especies comunes de árboles. Hoy día, la mayor parte de la isla está cubierta por bosques secundarios. En el 1956 se estableció el Parque Nacional de las Islas Vírgenes y ahora el Servicio de Parques administra alrededor de tres cuartas partes de la isla.

El reconocimiento preliminar se encontró como un 85% de las especies previamente reportadas para la isla, al igual que 130 especies adicionales que no habían sido reportadas anteriormente. Las Leguminosas constituían la familia mejor representada con 70 especies seguida por las Gramineas con 50 especies y las Euforbiaceas con 35 especies. También se encontraron 20 especies consideradas raras y amenazadas.

Se identificaron 127 especies de árboles en 31 estaciones de muestreo distribuidas a lo largo de las tierras del Servicio de Parques. Se clasificaron, tentativamente, por su preferencia a la humedad. Los bosques de los terrenos mas altos eran más ricos en la composición de especies y los bosques del litoral tenían el menor número de especies.

Vegetación de St. John y de la Isla Hassel

(Woodbury y Weaver 1984)

Los bosques originales de St. John fueron eliminados por la perturbación humana en el pasado. Al presente se encuentran en distintas etapas de recuperación y pueden clasificarse de la manera siguiente: manglar, salitral y laguna, 120 ha; bosque húmedo incluyendo el de altura, 460 ha, bosques de galería, 205 ha, y bosque de hoyas, 185 ha; formaciones perennifolias secas incluyendo montes, 1730 ha, maleza, 1110 ha, espinar y cacto, 325 ha, y pavimento rocoso de costa 110 ha; vegetación secundaria, 695 ha; pastos, 105 ha; y zonas urbanas, 135 ha. El área total comprende 5180 ha. Se prepararon listas de especies comunes para cada una de estas clasificaciones de bosques.

La Isla Hassel tiene 54.2 ha en tamaño y también contiene manglar, bosque húmedo de hoyas, maleza seca perennifolia, espinar y cacto, pavimento rocoso costero y maleza de Acacia, Croton y Leucaena.

Todas las especies se clasificaron por familia y forma de vida y además por su abundancia dentro de cada tipo de bosque. La isla de St. John tiene 116 familias y 792 especies. La Isla Hassel tiene 66 familias y 297 especies. De las 18 especies clasificadas como raras y en peligro de extinción, 6 podrían ser nuevas a la ciencia. Se describieron los usos medicinales para muchas de las especies.

Se prepararon mapas de vegetación para ambas islas y se incluyeron sugerencias para el manejo de los recursos forestales.

Estudios en progreso

Las investigaciones en plantaciones de enriquecimiento con caoba híbrida en el Bosque Experimental de Luquillo están casi terminadas. El estudio del efecto de los huracanes en la composición de especies y crecimiento en el bosque Colorado (bosque subtropical montano bajo muy húmedo) de La Sierra de Luquillo está casi completo, como también está el estudio de la vegetación de la cuenca de Cinnamon Bay en la Isla de St. John. Todo esto fué mencionado en la última Carta Anual.

Dos estudios adicionales casi terminados tienen relación con los estimados de la productividad primaria neta en el bosque enano (bosque pluvial subtropical montano bajo) en La Sierra de Luquillo y el muestreo del contenido de materia orgánica en los suelos de los bosques secundarios en Puerto Rico.

Proyectos Nuevos

En enero de 1984 se inició un inventario de los bosques de la isla de St. Vincent. Las técnicas usadas siguen de cerca las que se usaron en el inventario de los bosques secundarios en Puerto Rico reportados en la última Carta Anual. Además, se hizo un reconocimiento de las plantaciones forestales y se estimaron el volumen en pie y la tasa de crecimiento. Desde enero de 1985, se pondrá al día el inventario forestal de Puerto Rico del 1980. Este trabajo producirá datos sobre los cambios en el crecimiento de los árboles y en la composición de los rodales.

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OTROS ESTUDIOS EN BOSQUES NATURALES Y EN PLANTACIONES

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Investigaciones Terminadas

El Servicio Forestal de EE. UU. publicó una síntesis de la historia de las investigaciones y de las oportunidades de investigación en el Bosque Experimental de Luquillo (Brown y otros 1983). Este documento resume más de 200 trabajos científicos, producto de más de 40 años de actividades investigativas en el Bosque Experimental de Luquillo. Los tópicos incluyen hidrología, clima, geología, suelos, resúmenes del estado de los conocimientos sobre los mayores ecosistemas forestales e historial de catástrofes y danos naturales. El trabajo demuestra que la documentación de datos de largo término del Bosque Experimental de Luquillo es tan fuerte como la de cualquier otro bosque tropical en el mundo y quizás tan buena como la de muchos otros lugares de zonas templadas.

Hubo otra publicación en la cual se sintetizaron los datos disponibles de volumen para bosques tropicales (Brown y Lugo 1984). Estudios recientes de áreas de diferentes tipos de bosques tropicales y de sus correspondientes volúmenes, se usaron para calcular las densidades de biomasa y la biomasa total de los bosques tropicales. La biomasa total se estimó en 205 x 10^9 t (Tabla 1, pag. 5) y las densidades de la biomasa al pesarse por el área de bosques cerrados y bosques abiertos de hojas anchas fueron 176 y 61 t/ha, respectivamente. Estos valores son considerablemente más bajos que los informados previamente y levantan interrogantes acerca del papel que juega la vida terrestre en el presupuesto global del carbón.

El Instituto publicó un mapa ecológico provisional de la República del Brasil (Tosi y Velez-Rodriguez 1983) con la cooperación de varias instituciones (Departamento de Energia de EE. UU., El Centro de Investigaciones para la Energía y el Ambiente de la Universidad de Puerto Rico y el Centro Tropical de Ciencias). El mapa es a colores (a escala de 1;5,000,000) y lo acompaña una narración de 25 páginas. Brasil tiene tres de las siete regiones latitudinales reconocidas bajo el sistema de zonas de Vida: tropical (5.684 millones de km^2), subtropical (2.076 millones de km^2), y cálido templado (0.751 millones de km^2). El estudio describe 17 zonas de vida (9 en el trópico, 5 en el subtrópico, y 3 en la región cálido templada). Además, el mapa identifica algunas 10 u 11 zonas de transición. Todas se describen en la narración y los datos climáticos usados para preparar el mapa también se incluyen en un apéndice.

Como un primer paso hacia la preparación de un libro sobre los bosques en Puerto Rico, el Instituto publicó un compendio de artículos describiendo los tipos forestales en Puerto Rico (Lugo 1983). El compendio contiene 21 contribuciones, mayormente en español, de colaboradores de la Universidad de Puerto Rico, de agencias del Estado Libre Asociado y de otras instituciones en Puerto Rico y el exterior.

Se llevó a cabo un reconocimiento considerando la estructura del bosque de Dorado, la composición de las especies y los cambios en áreas del bosque durante mas de 44 años. El área cubrió 39.5 ha de terrenos forestales en Dorado, Puerto Rico (Figueroa y otros, 1984). H.A. Gleason y M.T. Cook habían estudiado las condiciones del bosque en el 1926 . Se encontró un total de 51 especies de árboles en el área estudiada. Se identificaron seis tipos forestales en arenas blancas y en suelos arcillosos de pobre drenaje. El bosque más complejo encontrado fue un bosque secundario de 19.7 m de altura con 32 especies, 1880 tallos/ha, un area basimétrica de 41.6 m^2/ha y un índice de complejidad de 493. Plantaciones abandonadas de palmas (5 especies), un bosque abierto perturbado conteniendo 9 especies de árboles y dominado por Hymenaea courbaril; un bosque Clusia-Zyzygium (11 especies de arboles), y un bosque secundario joven con 19 especies de árboles (también dominado por H. courbaril), estaban todos siguiendo la sucesión hacia el viejo bosque secundario. Este bosque se considera el climax en las arenas blancas. En los terrenos inundables, Pterocarpus officinalis y seis otras especies de árboles forman un climax de bosque de pantano que no ha cambiado en composición durante los últimos 54 años. En términos de área forestal, sin embargo, el Pterocarpus y el bosque viejo secundario se han reducido por 30 y 79 porciento, respectivamente. La causa primaria de los cambios en área de bosques ha sido la intervención humana: directamente, por desmontes, e indirectamente por cambios en las condiciones de drenaje. Estos bosques estudiados, sin embargo, contienen cuatro especies de plantas y una especie de pájaros en peligro de extinción. Los valores sociales, científicos e intrinsecos del bosque son significativos.

En las actas de una conferencia-exhibición celebrada en Paris para conmemorar el decimo aniversario del Programa del Hombre y la Biósfera se publicó un artículo sobre prioridades de entrenamiento e investigaciones en el trópico (Lugo y Brown 1984). El entrenamiento y las prioridades de investigaciones sobre el trópico necesitan re-evaluarse porque muchos de los documentos en la materia no están basados en síntesis abarcadoras acerca del estado de los conocimientos contienen numerosos conceptos erróneos y las prioridades recomendadas están fuera de foco. Los ejemplos en el artículo ilustran cada uno de estos problemas y sus consecuencias. El entrenamiento y las prioridades de la investigación para el trópico deben aparejarse al manejo y a las necesidades de la gente y a los límites en el uso de los recursos y a la producción orgánica impuestos por las leyes naturales. Los esfuerzos deben dirigirse a llenar lagunas existentes en conocimientos y enfocados a un ecosistema o a un nivel global de organizacion biologica, niveles donde se basan los problemas humanos mas críticos. Se propone una esquema organizativa para los campos de entrenamiento, manejo, investigación y planificación para coordinar estas actividades en el trópico.

Estudios en Progreso

Se terminó la parte de campo de varios estudios y se prepararon manuscritos para publicación. Estos incluyen un estudio en la dinamica de un ecosistema en un bosque de palmas creciendo en áreas inundables (hecho en cooperación con J.L. Frangi), una evaluación del crecimiento y producción en plantaciones de Anthocephalus chinensis (hecha en cooperación con J. Figueroa); un estudio en la estructura y biomasa del bosque seco de Guánica, y otro en los ciclos minerales del mismo bosque (ambos fueron hechos en cooperación con P.G. Murphy). Además, hemos continuado la cooperación con la oficina de Reconocimiento Geológico (US Geological Survey) y el Centro para la Investigación de la Energía y el Ambiente. Con esta cooperación hemos realizado estudios en las cuencas hidrograficas en las islas de Dominica, St. Vincent y Santa Lucía. Los estudios en las islas del Caribe son subvencionados por la Agencia de EE. UU. para el Desarrollo Internacional (AID) como parte de su contribución al Plan de Accion Ambiental del Caribe. En la última Carta Anual y en otros sitios de esta Carta se han descrito otros estudios conducidos bajo este proyecto. Los resultados de todos los estudios terminados se discutirán en futuras ediciones de la Carta Anual después que se publiquen los manuscritos o los informes.

Los manuscritos en preparación incluyen, uno en la comparación en ciclos minerales en plantaciones y en bosques naturales, y otro en la rapidez de producción y acumulación de biomasa en plantaciones de árboles tropicales. Ademas, se está estudiando el uso de plantaciones de especies tropicales para la producción de energía de la biomasa y sobre la rapidez de descomposición de madera en condiciones tropicales húmedos. En las futuras Cartas Anuales daremos énfasis a los resultados de estos estudios.

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INVESTIGACIONES SOBRE LA COTORRA PUERTORRIQUENA

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Produccion y Supervivencia de la Poblacion Silvestre de la Cotorra

En agosto de 1983 sobrevivían un mínimo de 30 cotorras en el Bosque Experimental de Luquillo. En un contaje de todo el bosque en febrero de 1984 habia un mínimo de 29 cotorras. Para agosto de 1984, la población consistía de un mínimo de 28 cotorras, a pesar de la adición de 4 cotorras.

Al principio de la época de la cría del 1984, la población adulta reproductora consistía de los mismos individuos que pusieron huevos en el 1983. Un miembro del grupo reproductor conocido se perdió durante la estación de 1984: la hembra de la Bifurcación Oeste (conocida desde el 1974 y que puso huevos desde el 1975) desapareció tarde en la época de cría.

Por primera vez desde el 1981, cuando una nueva pareja silvestre se apoderó de un nido de la tradicional pareja de cotorras de la Bifurcación Sur, un nuevo par de cotorras se añadió a la población reproductora. Este evento rebasa el significado de anadir la quinta pareja el número mayor de cotorras reproductoras desde el 1976. La nueva pareja (Bifurcación Este #3) había sido observada explorando sitios para nidos desde el 1982 en la Bifurcación Este. En esa área se habían provisto varias estructuras artificiales para anidar (construídas de tubería de cloruro de "polyvinyl") y se habían mejorado las cavidades naturales para las cotorras. La pareja había sido observada explorando tres de estos sitios. La aceptación de esta pareja de una de estas cavidades es especialmente importante porque representa un movimiento exploratorio exitoso de una pareja de cotorras en un área que no se conocía que hubiera tenido nidos de cotorras desde que principio el programa de investigaciones (1968). La pareja escogio una cavidad natural que habia sido mejorada por personal del proyecto.

Cinco pares de cotorras silvestres pusieron un total de 21 huevos en el 1984. En tres parejas correspondientes a (Bifurcacion Oeste, Bifurcacion Este #1 y Bifurcacion Este #2) se produjeron dobles nidadas experimentalmente en un esfuerzo para mejorar la produccion. Las primeras nidadas de dos de las parejas no se removieron hasta tarde en el periodo de incubacion despues que se determinara que todos los huevos en una nidada (Bifurcacion Este #1) eran infertiles y solo uno de tres huevos en la otra nidada (Bifurcacion Este #2) era fertil. Las tres parejas regresaron a sus nidos respectivos, pero solamente las parejas de la Bifurcacion Oeste y de la Bifurcacion Este #1 produjeron segundas nidadas. Por lo menos tres de los cuatro huevos producidos por la pareja de la bifurcacion Oeste eran fertiles, pero debido a la pobre calidad del cascaron no sobrevivieron ninguno de los embrios. Ninguno de los dos huevos producidos en la Bifurcacion

Este #2 en la segunda nidada fueron viables.

En total, el 28.6% de los huevos (N = 6/21) puestos por la población silvestre fueron fértiles. Continua la tendencia de fertilidad declinante en la población silvestre. La pareja de la Bifurcación Oeste puso ocho huevos con cascarón fino y ninguno empolló. La pareja de la Bifurcación Este #1 puso cuatro huevos pero ninguno fué fértil. Esta pareja consistió de un nuevo macho que sustituyó el macho tradicional (desde 1974) el que murió de causas indeterminadas en el 1983. La pareja de la Bifurcación Este #2 produjo un huevo fértil de los cinco puestos. Dos huevos de tres puestos por la pareja de la Bifurcación Sur fueron fértiles. La nueva pareja de la (Bifurcación Este #3) aparentemente produjo solo un huevo no viable. Ese huevo no se descubrió hasta agosto cuando los biólogos estaban mejorando la cavidad usada por la nueva pareja. El huevo fué puesto tarde en la estación de cría porque la pareja no había anidado en el sitio cuando éste fue examinado a mediados de abril.

Tres polluelos silvestres sacaron pero solo uno emplumó. Un polluelo silvestre murió de causas indeterminadas en el nido de la Bifurcación Sur. Su compañero de mayor edad sobrevivió, pero murió más tarde de una infestación masiva de las larvas de un nuevo parásito, la mosca soldado (Hermetia illucens). La mosca soldado no se ha informado a menudo como un parásito de aves vivas y se ha encontrado en el nido de la Bifurcación Sur en otros años, sin aparente efecto adverso en los polluelos de la cotorra. Después de la pérdida de los polluelos de la Bifurcación Sur otro polluelo silvestre (Bifurcacion Este #2) se crió con éxito en un nido del cual voló normalmente.

En total, cuatro polluelos emplumaron de nidos silvestres en el 1984. Tres de estos se habían producido en cautiverio llevados a nidos silvestres y uno era silvestre. Dos polluelos producidos en cautiverio fueron llevados al nido de la Bifurcación Oeste, después que los huevos de la pareja anidada allí probaron no ser viables. Estos fueron aceptados inmediatamente por la pareja tradicional, pero la hembra adulta con la pata rota desapareció tarde en el período de anidar dejando al macho solo para cuidar los polluelos. Como una medida de seguridad, dos polluelos de la cotorra dominicana (Amazona ventralis), sustituyeron a los polluelos de la cotorra puertorriqueña hasta que se pudo asegurar que el macho podía cuidar adecuadamente a los polluelos. Para complicar la situación, ocurrió un evento interesante cuando una cotorra se mudó al área del nido y se apareó con el macho tradicional. Inicialmente, el nuevo habitante no fue bien aceptado por el macho, pero eventualmente fue tolerado en el nido y le fue permitido entrar en la cavidad. El macho alimentaba al nuevo pájaro, pero la presunta hembra no participaba en el cuidado de los dos polluelos. Una vez que la situación en el nido de la Bifurcación Oeste se consideró suficientemente estable para reponer los polluelos de la cotorra puertorriqueña, éstos sustituyeron a los de la cotorra dominicana. Sin embargo, ninguno de los pájaros (los mismos que habían sido criados de nuevo sin problemas) emplumaron normalmente. Uno no se cree que sobrevivió. El segundo polluelo resultó estar atacado por larvas de una mosca (Philornis [Neomusca] pici) que lo inhabilitó para salir de la cavidad y tuvo que ser llevado a cautiverio para curarlo. Su rehabilitación tomó varias semanas y esta ave se retuvo como parte de la manada cautiva.

El desarrollo de un aparato telemétrico propio para las cotorras continuó en el 1984. Dos pichones de cotorras fueron provistos con nuevos collares transmisores diseñados de modo que se desprendan del ave después que las baterías se agoten (en cerca de 3 meses). El desarrollo de un sistema de telemetría es esencial para determinar causas de mortalidad temprana y para seguir los movimientos de los pájaros después de emplumar, de modo que se puedan desarrollar estrategias de manejo que mejoren la supervivencia.

Producción de Cotorras en Cautiverio

Al comienzo de la estación de cría del 1984 la manada de cotorras puertorriqueñas en cautiverio consistía de 23 aves, incluyendo 9 hembras de edad suficiente para poner. Siete de estas pusieron un total de 34 huevos. Dos hembras ("P2" y "P3") constituían una pareja homosexual tradicional, cinco hembras formaban parejas heterosexuales y dos no formaban parejas. Dos de las hembras en las parejas heterosexuales pusieron huevos infértiles, y una hembra sin aparear también puso huevos. Solamente las mismas dos parejas que han producido huevos fértiles en el pasado pusieron huevos viables. De los 34 huevos puestos por todas las hembras, 11 (32.4%) fueron fértiles. Las dos parejas fértiles pusieron 13 huevos de los que el 84.6% (11) fueron fértiles, y el 63.6% (7) sacaron. Todos los polluelos sobrevivieron hasta emplumar.

Cuatro de los siete polluelos producidos en cautiverio se adaptaron a dos nidos silvestres (Bifurcación Este #2 y Bifurcación Oeste), pero uno se removió del nido de la Bifurcación Oeste debido a un ataque de larvas de moscas que ponía en peligro su supervivencia al tiempo de emplumar. Los otros tres polluelos emplumaron en el monte. De los polluelos producidos en cautiverio, cuatro se retuvieron, lo que hace esta manada llegar a 27 cotorras nativas en cautiverio. La población total mundial de las cotorras puertorriqueña (eso es población cautiva y silvestre) llega a un mínimo de 55 aves.

Se han conducido varios experimentos como parte de un programa continuado para desarrollar métodos de aumentar la producción de cotorras cautivas. Se produjeron nidadas dobles en cuatro de seis parejas ponedoras. Todas las parejas asi manipuladas produjeron nidadas de reemplazo, aumentando así la produccion de 33.3% a 100% (promedio = 70.8 ± 27.8 [d.s.] %) sobre sus primeras nidadas (sin manipular).

Experimentos en la manipulación de las cotorras dominicanas tambien produjeron aumentos sustanciales en la producción de huevos. Seis hembras de estas cotorras (incluyendo una hembra sin compañero) produjeron un total de 39 huevos de los cuáles el 69.2% (27) fueron fértiles (79.4% de los huevos producidos por parejas heterosexuales). Tres de las parejas sin manipular produjeron un promedio de 4.3 ± 0.6 huevos por nidada. Una pareja de cotorras dominicanas fue inducida experimentalmente a producir una nidada substituta (nidada doble como en los experimentos con las cotorras nativas ya descritas) consistente de 6 huevos (39.5% mayor número de huevos que los que se produjeron en nidadas sin manipular). Otras dos hembras fueron inducidas a reemplazar huevos cuando estos fueron retirados del nido ("reemplazo subsiguiente"). Estas hembras produjeron una nidada promedio de

10 ± 2.8 huevos, o 66.7% sobre la producción de hembras con doble nidada y 132.6% mayor número de huevos que en las nidadas sin manipular.

Tres cotorras puertorriqueñas jóvenes están siendo entrenadas para un programa de inseminación artificial. Uno de los machos (de 18 meses de edad) ha establecido un vínculo especialmente estrecho con su entrenador humano y ha empezado a ofrecerle alimento en son de galanteo, lo que constituye una señal positiva de un buen vínculo de pareja.

OTRAS INVESTIGACIONES SOBRE LA VIDA SILVESTRE

Wayne J. Arendt
Biólogo en Vida Silvestre

Investigaciones en Puerto Rico

En cooperación con J. Faaborg de la Universidad de Misuri-Colombia se continuaron los estudios en el uso de mallas y de anillamento en el Bosque Seco de Guánica en el Suroeste de Puerto Rico. Se obtuvieron mas datos sobre el retorno anual de aves invernales norteamericanas y la parte que desempeñan en la comunidad de las aves (Faaborg y Arendt, en prensa). Aunque los datos sugieren mucha variación entre los individuos y las especies las "reinitas" (warblers) migratorias aparentemente caen en dos grupos diferentes: (1) una comunidad estable de residentes invernales que aparentemente está integrada por completo en la comunidad de aves del bosque de Guánica, y (2) un grupo de especies oportunistas cuyas poblaciones varían grandemente de año en año y que muestran poca fidelidad al sitio. Este último grupo abundó más entre 1974-1980 cuando las poblaciones residentes eran bajas respondiendo a condiciones de sequía repetidas durante la época de cría de las aves residentes (mayo-julio). Los estudios sobre anillamento continuaran en la esperanza de obtener la explicación de la proporción obliqua de sexos observada entre los warblers invernales, el área y los habitats necesarios para las especies aparentemente más móviles, el efecto de las densidades de los residentes sobre los residentes invernales y sensitividad en los residentes invernales que muestran altos niveles de "philopatry".

En un repaso al cabo de 9 años de los estudios de uso de anillas en el bosque de Guánica (Faaborg y otros, 1984) se ha demostrado que las fluctuaciones en la población de aves son proporcionales a la cantidad de lluvia especialmente antes y durante la época de cría. Las especies residentes en el bosque de Guánica pueden coexistir a traves de sequías severas sin ninguna pérdida a la especie porque los individuos simplemente se dispersaron a regiones mas amplias. La competencia entre estas especies durante tales "aprietos ecológicos" ha conducido a los patrones estructurales simples y conservadores que encontramos en las comunidades de aves de las Indias Occidentales.

Investigaciones Regionales

Durante este año se continuaron evaluaciones en ocho islas antillanas (Antigua, Barbuda, Dominica, St. Lucia, St. Vincent, dos islas en las Granadinas y en Montserrat). En cada isla se evaluó el estado de la vida silvestre vertebrada en relación a las necesidades de sus habitats. Se observaron algunas tendencias generales, aunque las especies de vida silvestre, el clima, la composición de la vegetación y las causas y extensión de la perturbación del habitat variaron de isla a isla. Por ejemplo:

- Los tipos de bosques nativos o indígenas ya no existen o están reducidos grandemente. La vegetación secundaria resultante es menos propia para la vida silvestre nativa de la cual muchas especies están adaptadas a habitats en bosques primarios.

-Las especies más abundantes de vida silvestre se adaptan a áreas perturbadas o son especies generalistas que pueden sobrevivir en una variedad de habitats naturales o perturbados.

-Los animales introducidos continúan presentando una seria amenaza a la fauna y a la flora nativa.

-La deforestación continúa amenazando la conservación de la fauna y de la flora nativa.

En cooperación con la Compañía Nacional de Montserrat se realizaron evaluaciones de la vida silvestre para estudiar el estado, distribución y ecología reproductiva del ave nacional de Montserrat, el "Montserrat Oriole" (Icterus oberi). La mayor concentración de los "orioles" se encontró en la región de "South Soufriere Hills" de Montserrat en bosques mesofíticos empezando a una elevación de 336 m cerca del "Bamboo forest" y continuando hacia arriba a través de bosque higrofítico hasta un bosque enano a 671 m en una elevación conocida localmente como "Upper Pond". Se encontraron ocho parejas de cría por km. Sin embargo, no se encontraron "orioles" en la cumbre de la montaña más alta de Montserrat, "Chanceis Peak" (915 m) donde el bosque enano consistente mayormente de bosque de palmas, ha estado impactado constantemente por vientos fuertes y ocasionalmente por huracanes. Tampoco se encontró esta especie en el crecimiento secundario altamente degradado en el vecino "Gage's Peak". Sin embargo, encontramos "orioles" en los desfiladeros escarpados separando ambos picos. A pesar de una concentración mas baja de los "orioles" (solo 3 parejas de cría por km). En la vegetación secundaria de un rodal en un bosque mesofítico en las "Centre Hills" se encontraron parejas de "orioles" en la vegetación riberena a lo largo de los arroyos que bajaban de los desfiladeros muy húmedos y hasta bien adentro de las llanuras. Solo se encontraron ocasionalmente parejas de "orioles" en la altamente degradada vegetación secundaria en los "Killiekrankie Water-Works". Tampoco se encontraron en los bosques xerofíticos pero ocasionalmente se han informado individuos de estos sitios. También se llevaron a cabo estudios intensivos de la ecología reproductiva de los "orioles". Estos estudios están siendo preparados para su publicación.

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INVESTIGACION COOPERATIVA CON LA UNIVERSIDAD DE WISCONSIN SOBRE LA VIDA SILVESTRE

Eduardo Santana Castellón
Biólogo en Vida Silvestre

En el 1984 terminé estudios sobre la vida silvestre con el Dr. Stanley A. Temple del Departamento de Ecología de la Vida Silvestre en la Universidad de Wisconsin. Estas investigaciones sirvieron de base a la tesis para mi grado de maestría en ciencias.

Halcones de Cola-Roja (Guaraguao)

Encontré altas densidades de guaraguaos en el Bosque Experimental de Luquillo. Las densidades eran más altas que las de las llanuras adyacentes al bosque y de aquellas informadas en Norteamerica. El éxito de la reproducción fué normal en las llanuras, pero bajo en el bosque pluvial. Una causa aparente de este fenómeno fué la frecuencia de las lluvias y niebla que redujeron la frecuencia de la alimentación a los nidos en el bosque pluvial. Hubo un cambio pronunciado en la composición de la dieta de estos halcones a lo largo de una pendiente de elevación de una dominada por mamiferos en la llanura a una dominada por reptiles y pájaros en los bosques nublados de la montana. Los patrones de actividad del guaraguao en el bosque fueron estudiados por individuos equipados con radio-transmisores. Los halcones resultaron ser una amenaza para las cotorras puertorriqueñas en los valles donde éstas se procrean y alimentan.

Con la colaboracion de Eddie N. Laboy del Departamento de Recursos Naturales de Puerto Rico y James A. Mosher de la Universidad de Maryland se estudió la estructura de nidos del guaraguao. Se encontró que los halcones hacían sus nidos en los árboles que sobresalían sobre el nivel promedio de las copas en el rodal y en las ramas horizontales en la cuarta parte superior del árbol. Los bejucos ayudaban a sostener los nidos en habitats húmedos, pero no asi en habitats secos. Los nidos se encontraban mas frecuentemente en la mitad superior de las laderas en áreas protegidas de la interferencia humana. Las características de la vegetación y de la topografía convergían en facilitarle a los halcones poder observar gran parte del territorio desde el nido. Se establecieron contrastes entre areas para nidos en zonas templadas y tropicales. Se describieron las características mas sobresalientes del área para nidos del guaraguao para ayudar a los que manejan la vida silvestre a evaluar la calidad de secciones de bosques adaptados a estos halcones en Puerto Rico; al mismo tiempo proveyó al Departamento de Recursos Naturales recomendaciones sobre el deporte de la falconería.

Radio Transmisores para las Cotorras

En un esfuerzo conjunto con el Servicio de Pesca y Vida Silvestre de EE.UU., se desarrolló un modelo de radio-transmisor para ayudar a los investigadores en los proyectos de cotorras a determinar los movimientos y las fuentes de la mortalidad de las cotorras de Puerto Rico. El diseño actual corriente de los transmisores (e.g., arnes, rabo, encoladura, y monturas en el torso) no funciona con las cotorras. El único sistema de sostener la radio que las cotorras toleraron fue un modelo ajustable de collar del cuello con una antena de una sola vuelta. Este modelo se diseñó de manera que se desprendiera del cuello de la cotorra una vez que la batería se agotara. Transmisores que se diseñaron siguiendo el que se describe aquí fueron probados por el Dr. James W. Wiley del Centro de Investigaciones Patuxent para la Vida Silvestre en experimentos en la liberación de cotorras en la República Dominicana.

Auras

En Puerto Rico los estudios en la biología del aura se condujeron a la vez que los estudios del guaraguao. Greg Potter, un estudiante de escuela superior residente en Puerto Rico colaboró en este proyecto. Sean Furniss del Refugio Nacional de Vida Silvestre de Cabo Rojo y el Dr. Jose Vivaldi del Departamento de Recursos Naturales, proveyeron el respaldo logístico. Víctor Apanius de la Universidad de Wisconsin, ayudó en este estudio y condujo su propia investigación en la estructura y concentración de las immuno-globulinas del aura. La densidad de esta ave aumentó gradualmente del este hacia el oeste a lo largo de la costa sur de Puerto Rico. La densidad se correlacionó con patrones climáticos y de uso de la tierra. La actividad de vuelo fué mayor entre las 1000 y 1700 horas. El tamaño de su territorio, el patrón de movimiento y el uso de áreas de descanso fueron estudiados siguiendo a un aura equipado con un transmisor de radio.

Investigaciones en Costa Rica

Viaje a Costa Rica con la ayuda del Instituto de Dasonomía Tropical y de la Organización para Estudios Tropicales para estudiar cómo las propiedades de las frutas y modo de alimentación afectan la selección de alimentos de las aves frugívoras neotropicales. Este trabajo se realizó de manera cooperativa con los Doctores, Timothy C. Moermond y Julie S. Denslow de los Departamentos de Zoología y Botánica (respectivamente) de la Universidad de Wisconsin. Se realizaron experimentos para determinar los habitos alimenticios de *Aracaris* y "trosons" de cola color pizarra en cautiverio. Estas especies están consideradas como agentes importantes en la dispersión de semillas grandes de árboles (e.g., Lauraceas y Myristicaceas) y exhiben las dos adaptaciones más extremas para alimentarse de semillas. Los *Aracaris* (tucanes) brincan activamente en las ramas y obtienen la mayor parte de los frutos utilizando sus largos picos. En contraste, los "trosons" raramente caminan e invariablemente obtienen el fruto mientras vuelan. Los pájaros mostraron fuertes preferencias entre los frutos que se diferencian en tamaño, madurez, color, accesibilidad, altura sobre el terreno y la distancia hasta las hojas que los rodean. Sin embargo, ambas especies respondieron diferentemente a estas propiedades sugiriendo diferentes criterios fundamentales en sus habilidades de procurarse el alimento.

ESTUDIOS ESPECIALES

Frank H. Wadsworth
Dasónomo en Investigaciones

El proyecto mayor en esta sección del Instituto, la preparación de un manuscrito para un libro sobre la producción forestal para la América tropical, se encuentra en su fase final. Se han editado tres capítulos, se han recibido críticas en otros cuatro y dos más están casi listos, dejando dos capítulos que necesitan completarse. Una bibliografía de algunas 3,500 referencias se ha entrado en un procesador de palabras para facilitar la separación final y la uniformidad del formato.

Un análisis del crecimiento en diámetro durante 30 años de algunos 1,600 árboles con potencial para la producción de madera en rodales ecológicamente estables en el Bosque Experimental de Luquillo (Subtropical muy húmedo), está demostrando una relación significativa al sitio, a diferentes períodos de tiempo y a factores de predicción del crecimiento.

La Tabla 1 (pág. 16), al presentar datos de 24 años de las 6 especies más abundantes, ilustra la gran uniformidad de los promedios de crecimiento en contra de los cuáles se comparan las variaciones individuales. El análisis se sigue en cooperación con la Universidad de Yale.

Se comenzó un nuevo estudio del funcionamiento de las plantaciones de árboles maderables en Puerto Rico y en las Islas Vírgenes. Los records de cientos de estudios pasados realizados en todo el área se han seleccionado para una presentación consolidada. Algunas 200 plantaciones han sido seleccionadas para una evaluación final en el campo. De éstas, 18 han sido remedidas.

Se generaron cuatro ediciones del ISTF NEWS, la Carta Noticiosa Trimestral de la Sociedad Internacional de Dasónomos Tropicales y distribuída alrededor del mundo a más de 1000 miembros. La Carta Noticiosa es un producto de revisiones de adquisiciones nuevas de todo el mundo sobre dasonomía tropical a la biblioteca del Instituto, incluyendo artículos de revistas, evaluando su importancia y preparando críticas de los que se consideraron de mayor significado. Durante el año se describieron un total de 75 publicaciones y se hicieron resumenes de varios libros. La Carta Noticiosa se está publicando ahora en francés, como también en inglés y en español.

OTRAS ACTIVIDADES

JoAnne Feheley y Ariel E. Lugo
Técnica de Biblioteca y Líder de Proyecto

El personal científico del Instituto participa en actividades estatales, nacionales, e internacionales que promueven la investigación dasonómica tropical y/o diseminan los resultados de la actividad investigativa. Estas actividades están resumidas en las Tablas 1 y 2 (pags. 18 y 19). Además, el Instituto sirvió de anfitrión a muchos visitantes (Tabla 3, pág. 19) y condujo un número de actividades importantes como se informa a continuación.

En octubre de 1983, el Instituto sirvió de anfitrión al Comité de Investigaciones de la Comisión Latinoamericana de Dasonomía. El Comité desarrolló un plan de trabajo que incluía una síntesis de la producción de las plantaciones en la América Latina. Los datos requeridos para esta síntesis han sido reunidos cooperativamente por muchos países y se están analizando en Costa Rica.

El Instituto también fué instrumental en organizar la segunda reunión de Dasónomos del Caribe en Kingstown, St. Vincent, y las Grenadinas durante la semana del 19 de marzo de 1984. La reunión fué patrocinada por el Programa del Hombre y la Biósfera de EE.UU. por medio de su Directorio en Bosques Tropicales. Un total de 57 delegados asistieron procedentes de nueve islas. También había representantes de tres países adicionales (Canada, Haiti y Estados Unidos); y otras seis instituciones (Agencia Canadiense de Desarrollo Internacional, Agencia de EE.UU. para el Desarrollo Internacional, la Organización de los Estados Americanos, el Servicio Forestal de EE.UU., la Universidad de Illinois y el Servicio Geológico de EE.UU.). La reunión se dedicó al manejo de las cuencas hidrográficas. Cada isla presentó un trabajo resumiendo la condición de los programas y los problemas de las cuencas de su país. Entonces se hicieron presentaciones técnicas en la materia por los especialistas invitados. Se editarán todas las presentaciones para publicarse en las actas de la reunión.

Entre los objetivos primarios de la reunión, estaban el estimular las comunicaciones entre los dasónomos de las islas, revisar las actividades forestales celebrándose en el Caribe, la discusión de los problemas de interés común y el desarrollo de una agenda para acción futura coordinada en el área de manejo de cuencas. Los participantes a la reunión desarrollaron una serie de recomendaciones a todas las instituciones que tengan que ver con cuencas en el Caribe. Las recomendaciones se presentaron como una propuesta para la acción integrada de las cuencas de las islas.

Los hallazgos claves del taller de trabajo fueron que:

-El manejo de las cuencas es crítico para la protección de los limitados recursos de las islas del Caribe, e.g., tierras, bosques, suelos, agua, vida silvestre y los ecosistemas del litoral. Sin una base propia de recursos naturales, no se puede sostener el desarrollo económico en las islas del Caribe.

-Los recursos naturales de las islas son la piedra augular de su desarrollo. El sector forestal puede hacer contribuciones significativas por medio de sus actividades en el manejo de cuencas hacia la meta de hacer óptima y perpetuar la contribución de los recursos naturales a la economía de las islas.

-Debido a que el sector forestal de las islas del Caribe ha sido descuidado durante muchos años, es necesario que se estimule al punto donde pueda llevar a cabo su papel óptimamente en la economía.

El taller reconoció que:

-Los problemas de las cuencas hidrográficas se han tornado gradualmente mas críticos y se necesitan acciones inmediatas para conservar las opciones que pueden perderse si continúa dominando la presente inacción.

-Los recursos económicos necesarios para poder neutralizar estas preocupaciones están a menudo mas allá de las posibilidades de estas pequeñas islas. Por lo tanto, confiamos en la comunidad del desarrollo internacional para que nos ayude a realizar este esfuerzo tan necesario.

Las recomendaciones del taller fueron:

-Que se aplique a los problemas de las islas la tecnología ya desarrollada. Que estas tecnologías puedan mitigar las décadas de descuido en este sector y que puedan proveer medios poderosos que han probado ser útiles en otras partes del mundo.

-Que se implemente un programa coordinado de desarrollo de manejo de cuencas integrado a una estrategia amplia del sector forestal.

La Universidad de Yale en cooperación con el Departamento de Recursos Naturales de Puerto Rico y con fondos provistos por la Fundación Mellon, ha establecido un Instituto de Investigaciones Tropicales que usará a Puerto Rico como base para las investigaciones graduadas de los estudiantes. El Instituto cooperó con este esfuerzo y anticipamos un intercambio mutuamente beneficioso de información científica entre todas las instituciones participantes.

Durante este otoño, J. Fehely asistió a una reunión patrocinada por la dirección del Sistema de Información del Servicio Forestal de EE.UU., Washington, D.C. Los centros de información de investigaciones de la agencia estuvieron representados. Ellos formularon recomendaciones dirigidas al Jefe del Servicio Forestal para que desarrolle un sistema de información técnico-científico o una red que supla más efectivamente a los empleados del Servicio Forestal y de otras agencias con la información necesaria. Esta red incluiría entre sus componentes un archivo bibliográfico y una expansión de los servicios de entrega de documentos del Instituto.

En septiembre de 1984, se publicó una bibliografía de la dasonomía en Puerto Rico recopilada por Menandra Mosquera y JoAnne Feheley y publicada como el Southern Station General Technical Report SO-51. La bibliografia está parcialmente anotada y provee las fuentes de la literatura dasonómica de Puerto Rico y los campos relacionados e incluye referencias escritas entre 1889 y 1978.

El Instituto celebró los siguientes acuerdos cooperativos de investigación durante el año: Departamento de Dasonomía y Conservación de Suelos de Jamaica; Corporación Nacional de Reforestación, Venezuela (CONARE); Servicio de Investigaciones Agrícolas de Carolina del Norte, Escuela de Recursos Forestales, Universidad del Estado, Raleigh, Carolina del Norte, EE.UU.; Companía Nacional de Montserrat [Indias Occidentales]; Escuela de Dasonomía y Estudios Ambientales, Universidad de Yale, New Haven, Connecticut, EE.UU.

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